SAE JOURNAL

JUNE
1954

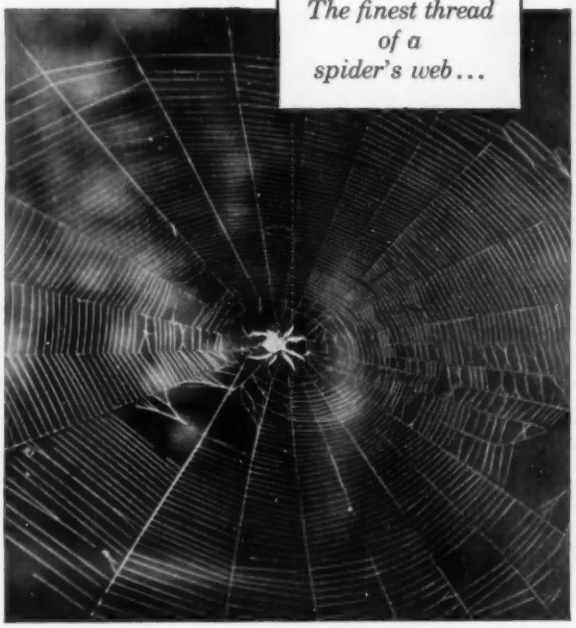
IN THIS ISSUE . . .

- TRUCK DRIVE LINES being prepared to travel in fast company of coming V-8's . . . page 17
- TEAPOT TEMPESTS push "pistons" out of aircraft auxiliary power jobs . . . page 21
- ARCTIC COLD and gloom no longer bar air operations . . . page 34
- SHOT PEENING improves fatigue life on over 400 P&WA engine parts . . . page 44
- ACCUMULATOR takes deluge of calls for car hydraulic-assists . . . page 47

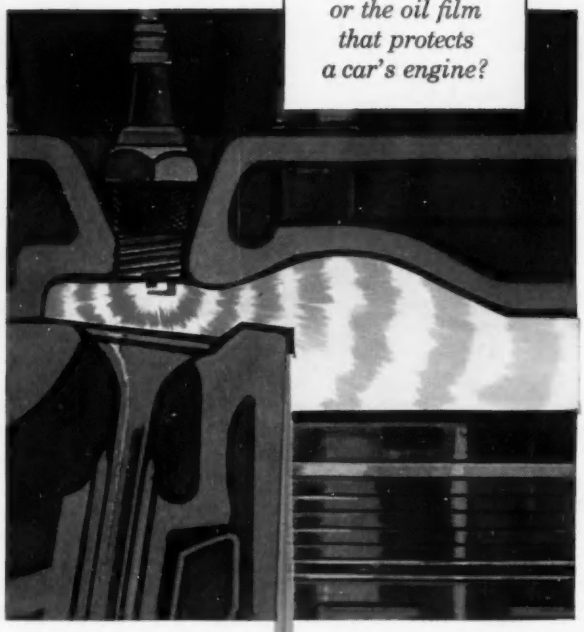
PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

WHICH IS *THINNER?*

The finest thread of a spider's web...



or the oil film that protects a car's engine?



Incredible...but even though the finest thread in a cobweb measures only .00024 of an inch in diameter*, it is still *10 times thicker* than the oil film that lubricates the top of cylinders and pistons.

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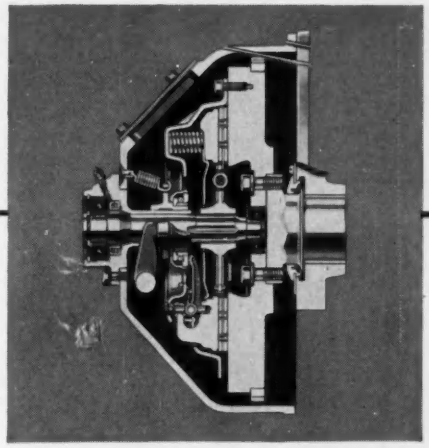

Cutaway shows New Departure **ball** bearing application in the clutch shaft and pilot positions.

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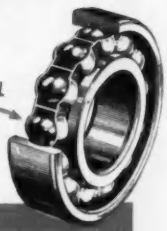

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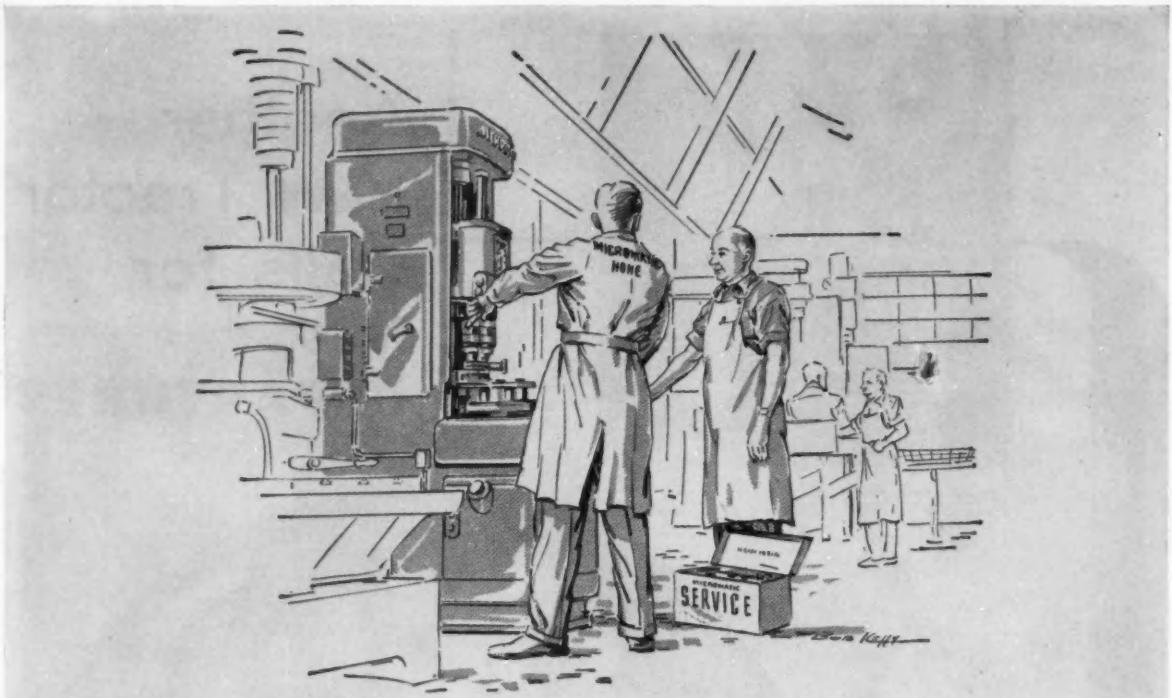

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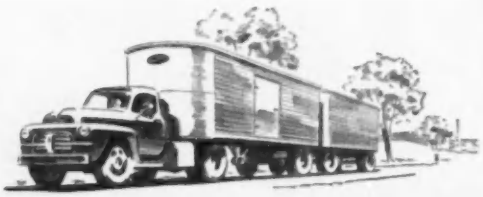

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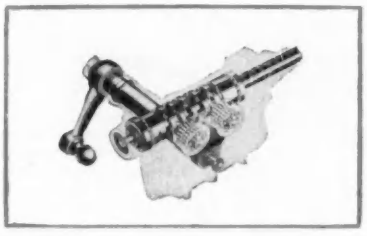
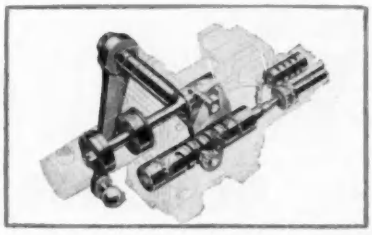
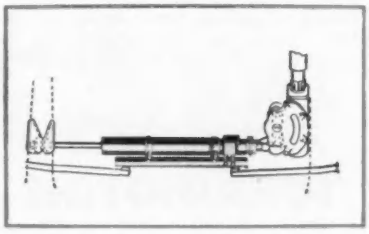
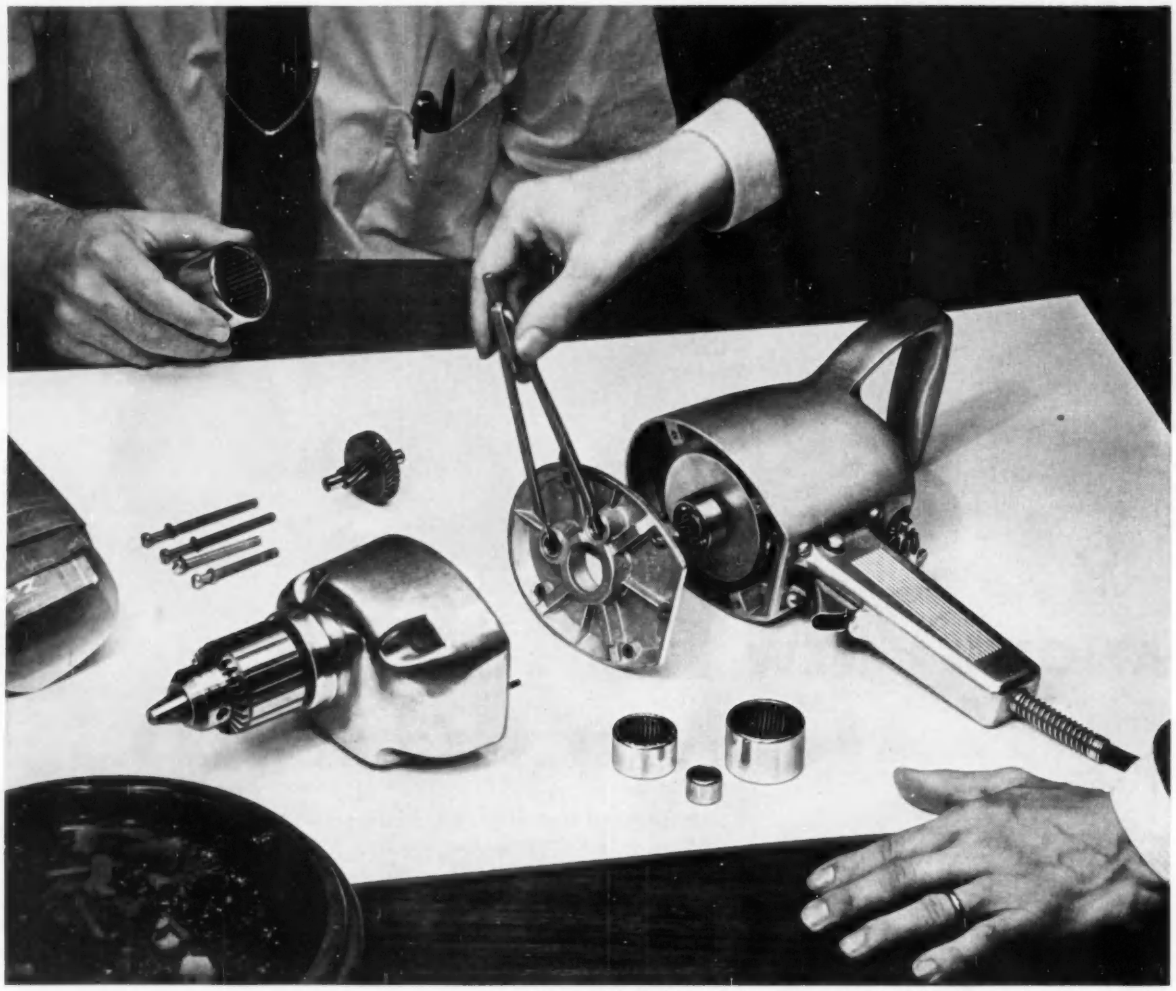






CAM & LEVER MANUAL...HYDRAPOWER INTEGRAL...HYDRAPOWER LINKAGE



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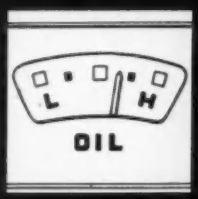

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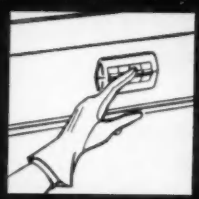

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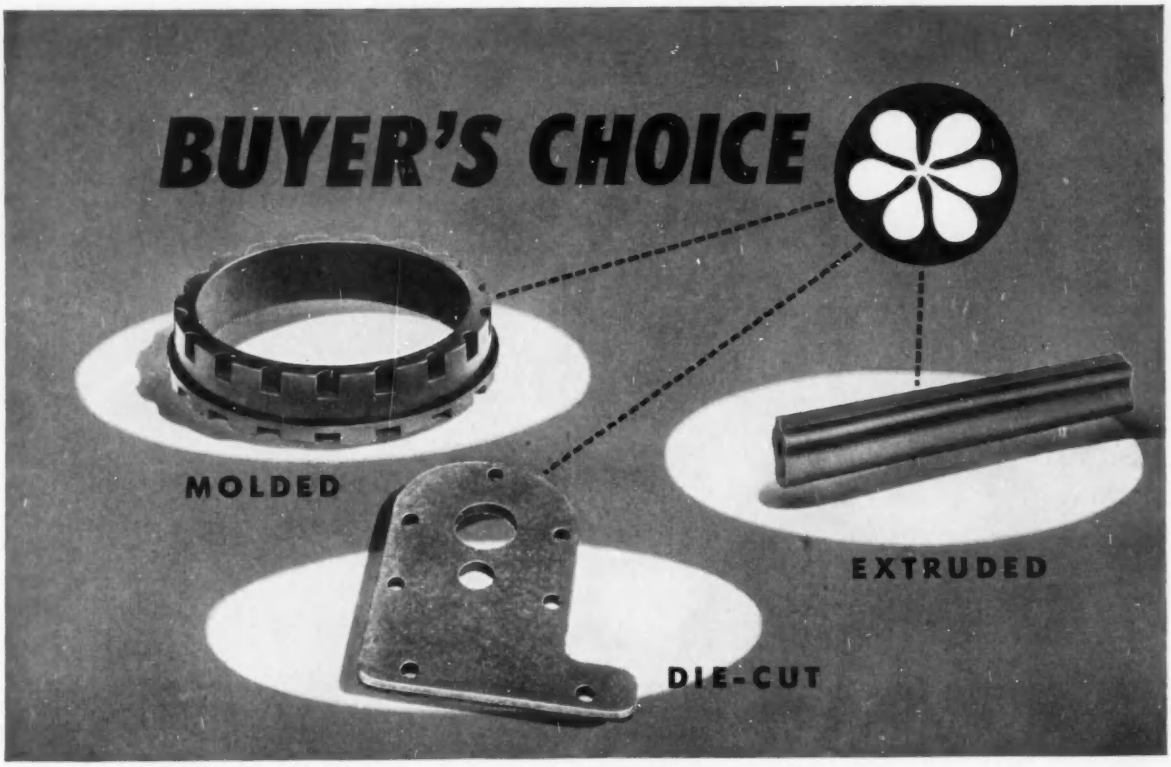

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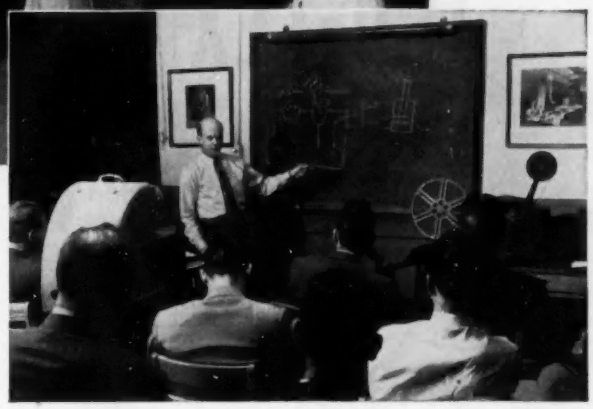

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For the Sake of Argument

Convinced, but not Convincing . . .

By Norman G. Shidle

"He sounded convinced, but not convincing," an executive friend said of an associate following argument about a policy decision recently. "The more emphatic his opinions became, the less effect they had on the rest of the group. As he turned on more and more heat, he cast out less and less light."

We weren't present at the discussion, so we can only guess at the accuracy of our friend's report. But it happens to all of us one time or another. We get to arguing without any clear picture of exactly what we are trying to achieve. One tangential comment leads to another. Before we know it we're leaping dizzily from crag to crag like the fabled alcoholic chamois. Finally, no party to the debate can remember how it got started, let alone where it was supposed to be going.

These tangential tangos are danced by partners in business conferences almost as much as by Aunt Hattie's sewing circle. Lacking a leader, though all the chairs be full, the conference can start for a back fence and wind up in outer space. Everybody is convinced; nobody is convincing.

Yet this dispersion is often refocused when even one conferee stops cold and asks himself:

"What am I trying to accomplish? What is *my* aim in this discussion?"

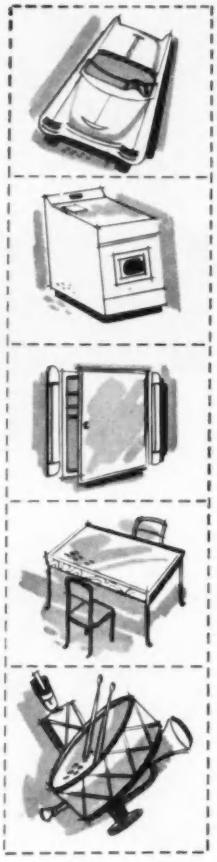
Few of us will admit to ourselves that we're trying to put our associates in their place; to make ourselves look good at another's expense; to get our own way . . . or that we're just plain ornery.

At worst, we won't admit to a completely negative objective. A very least rationalization is likely to be that we aim to convince the others of our viewpoint.

Even the limited objectivity of that aim starts us thinking in terms of the other fellow's reception; not just of our own outpouring. It starts the refocusing process in one mind. One member of the group begins to sound convincing, but not convinced, about his own views. . . .

And then there's a chance his ideas will be catching. Refocus may set in on the whole group . . . particularly if the stop-look-and-listen chap happens to be the chairman.

LESSON IN STAYING PUT



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PARCO LUBRITE wear resistant for friction surfaces

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Contents—June, 1954

Stiffer Needs Emerge For Truck Drive Lines—W. P. MICHELL 17

Teapot Tempests Come of Age—HOMER J. WOOD 21

How-Best-to-Do-It-Methods—J. A. MAURICE 24

Ride and Vibration Instruments—B. E. O'CONNOR 27

Aircraft Tooling Finds Jet Age a Challenge—K. H. BOUCHER 28

The Arctic Yields To The Military Airplane—COL. BERNT BALCHEN, BRIG.-GEN. THOMAS J. DU BOSE, LT.-COL. JOSEPH O. FLETCHER, COL. ANDREW E. KRIEGER, JR., EINAR PEDERSEN, PAUL A. SIPLE 34

Fit The Machine to The Driver—ROSS A. McFARLAND 41

P&WA Is Shot Peening Over 400 Parts—H. J. NOBLE 44

Accumulators Can Deliver More Car Hydraulic Assists—GEORGE W. LEWIS 47

Minimizing Cost of Forgings Requires Right Combination of Men, Materials, Machines—HOLLOWAY KILBORN and R. T. HERDEGEN, JR. 50

Designers Spell Out Ways for Cooling Innards of Supersonic Jets—DOYLE C. WELLS and GEORGE A. LEMKE 52

Three Steps for Controlling Manufacturing Costs—N. B. DAVIS, JR. 56

Mexican Hat Combustion Chamber Used in New Mack Diesel—BRUNO LOEFFLER 59

It's Still 12 Volts!—H. L. HARTZELL 63

Report of 1954 SAE National Aeronautic Meeting and Production Forum .. 64

Report of 1954 Central Illinois Section Earthmoving Industry Conference .. 75

■

Technical Committee Progress 80

About SAE Members 82

SAE Section Meetings 87

National Meetings Schedule 96

News of SAE 96

You'll Be Interested to Know 96

SAE Student News 97

SAE Section Meetings Schedule 97

Technical Digests 98

New Members Qualified 116

Applications Received 120

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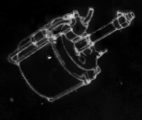

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Stiffer Needs Emerge For Truck Drive Lines

That's if they're going to travel in the fast company of coming V-8's

W. P. Michell, Chief Development Engineer, Spicer Mfg. Division, Dana Corp.

Based on paper "Drive Line for High Speed Truck Engines" presented at SAE Annual Meeting, Detroit, Jan. 11, 1954. This paper will be published in full in 1954 SAE Transactions.

THERE's a rumor that several truck engines on the way will be V-8's with speeds almost double those of current 6-cyl engines. (See Fig. 1.) If this is a fact, then all units back of these engines—clutch, transmission, propeller shaft, and rear axle—will have to be modified. Here are some of the changes that will be necessary:

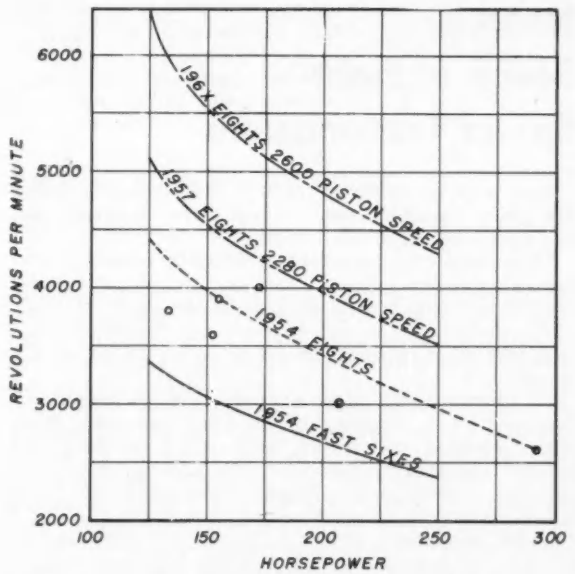


Fig. 1—Rumor has it that high-speed truck V-8's are on the way . . . and they're going to need drive lines to match

- **Clutches** will have to be smaller in diameter.
- **Propeller shafts** will have to be shorter and made of larger tubes with lighter walls. They will also have to be better balanced . . . and operate at reduced angles.
- **Rear Axles** will have to have larger ring gears, permitting single-reduction ratios of eight to nine.
- **Transmissions** will have to have not less than seven or eight usuable speeds—with wider steps at the low end and closer steps at the high end.

Probably the best way to bring out the drive-line problems that tomorrow's high-speed engines will introduce is to set up a hypothetical future highway vehicle combination.

Let's assume a tractor-tandem axle trailer with the following specifications: gross combination weight—55,000 lb, tires—11.00 by 20, width—8 ft, height—10 ft, cruising speed—50 mph, and maximum speed—60 mph.

Using the conservative figures in the SAE Truck-Ability Prediction Procedure, such specifications would call for about a 190-hp engine that could deliver a maximum torque of 300 lb-ft. (Assuming a 1.18 bore-stroke ratio and 110 bmep at governed speed, this engine would have a stroke of 3-27/64 in., a bore of 4 in., and a displacement of 345 cu in.)

Now, 192 hp could be expected from this engine at about 4000 rpm—a speed which would pose many a drive-line problem.

—Continued on Next Page—

Need 1:
Smaller Diameter Clutches

For example, at 4000 rpm, the peripheral speed of a 14-in. clutch would be too fast for safety. Thus, it may be necessary to use smaller, multi-plate clutches . . . or new materials.

Clutch inertia at higher speeds will be a problem too. Right now about two-thirds of the inertia that synchronizers have to overcome comes from clutches. And if we were to use present clutch sizes with 4000-rpm engines, this inertia load would roughly double (since inertia varies roughly with the square of speed). Here again, a smaller clutch would seem to be the answer. Otherwise, the transmission designer will have to use larger synchonizers or reduce the speed change between shifts.

Need 2:
Shorter, Larger, Lighter Propeller Shafts

Propeller shafts, too, will eventually have to be redesigned to work with the coming high-speed V-8's. With them, the problem can be stated quite simply: For a given torque capacity, they will have to carry a lot more speed.

Actually, several companies now offer propeller shafts that can meet the requirements of 4000-rpm engines. But even they can't be used with overdrive transmissions.

Therefore, we can foresee a need for these changes in propeller-shaft design:

1. Larger tubes, with lighter walls (for higher critical speed).
2. Reduced permissible length (for higher critical speed).
3. Closer balance limits on all components.
4. Reduced permissible operating angles.
5. Reduced permissible out-of-parallel angle of end flanges, that is, engine, center bearing, and axle pinion will have to be held to closer parallelism.
6. More attention given to mountings, particularly the midship or center bearing which now sends considerable vibration into the frame.

Need 3:
Greater Single-Reduction-Ratio Axles

Unlike propeller shafts, axle shafts (and differentials) won't be affected designwise by the advent of the high-speed V-8 engines. This is because their speed is limited by law . . . and their load by road grades and legal loads allowed.

Axle ratios will, however, have to be changed. With this in mind, let's consider the possibilities of six different axle and transmission combinations. (See Table 1.)

Combination A can be eliminated as a useless speed-up of transmission mainshaft, propeller shaft, and axle pinion.

Combination B will have to be ruled out (until better propeller shafts become available) because of excessive propeller shaft speed in overdrive. (Having rejected both of these combinations, we will not go into overdrive transmissions with two-speed axles.)

Combination C will be acceptable in those fields where an overdrive speed is not now required.

Combination D will be acceptable where an extra or overdrive speed is now required. This unit would run quietly with low losses in cruising, and without excessive noise at 60 mph.

Combination E will interchange with combination C. The two-speed ratio increases the overall low gear and splits the transmission ratios.

Combination F is interchangeable, saleswise, with combination D. More care will have to be used on the drive line, since it will always run at 4000 rpm.

Since none of the axle ratios is less than 8 to 1, the present single-reduction axle (whose limit is 7 or 7.5) seems to be unusable with the high-speed V-8's of the future.

Combination D is a compromise solution (cruising in 1.2 transmission reduction). But economics will not permit any great transfer of reduction from the axle to the transmission. This adds to the load on all drive parts—from transmission input to axle ring gear.

This is another way of saying that we can't get around high speeds by reducing them in the transmission.

It seems, then, that larger axle ring gears, permitting single-reduction ratios of 8 to 9, will be necessary. This, in turn, means new housing tools.

Need 4:
Seven or Eight Speed Transmissions

One way or another, future high-speed engines are going to affect both the physical makeup and the speed ratios of transmissions.

If the new engines simply run up the speed, gaining horsepower and not torque, the result will be higher cycles per mile on gear teeth and bearings. This would call for larger gears and bearings, particularly since dynamic forces on teeth increase with speed.

If, however, the new engines run up speed but reduce torque, keeping horsepower constant, then the increased cycles per mile must be balanced against the greatly increased life of gears and bearings with lower loads. Higher dynamic tooth loads would, however, offset some of this gain.

Noise, vibration, and unbalance will also require design and manufacturing changes of some magnitude. But these can be handled.

With higher speeds, transmission oil level will be

Table 1—Possible Axle and Transmission Combinations[a]

Combination	Cruise Speed mph	Fast Speed mph	Transmission High	Axle High	Axle Low	Propeller Shaft Speed at 50 mph	Propeller Shaft Speed High
A—Overdrive transmission, cruise in overdrive	50	None	0.83	11.6	—	4800	4800
B—Overdrive transmission, cruise in 1.0 ratio (Direct)	50	60	0.83	9.65	—	4000	4800
C—Direct transmission, cruise in 1.0 ratio (Direct)	50	None	1.0	9.65	—	4000	4000
D—Direct transmission, cruise in 1.2 ratio	50	60	1.0	8.05	—	3300	4000
E—Direct transmission and two-speed axle, cruise in high axle	50	None	1.0	9.65	12.0	4000	4000
F—Direct transmission and two-speed axle, cruise in low axle	50	60	1.0	8.05	9.65	4000	4000

[a] All combinations are suitable for manual or semi-automatic transmissions

critical too. Even now, temperature rise is serious in overfilled transmissions. Thus, it will be important to shoot for low oil level or dry sump.

As for transmission ratios, judging from past practice and new designs now under study, we will have:

1. Not less than seven or eight usuable speeds.

2. Ratio steps closed up or gathered near the high end, if shifting and gear pattern permit, or more steps provided for equal performance.

3. Transmission range reduced only if increased horsepower is available.

If a torque converter or fluid drive is used, the gear steps must follow the same pattern.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Excerpts from Discussion by . . .

Leo A. Bixby

Bixby Management & Engineering Counsel

APPARENTLY the trend of the truck industry is to increase the rpm of engines, with a proportional increase in hp. Therefore, this, in all probability, will bring about changes in the drive line of the vehicle transmission, propeller shafts, and axles.

However, today many of us have the problem of greater hp engines being used, with very little increase of speed, in the same truck and with the same load conditions as with the past lower hp engines. In theory, therefore, we would not substantially increase the speed of the vehicle over what it is today, but in actual operation we will be maintaining a higher sustained speed. So it gets back to doing more work through the drive-line units to overcome the frictional-hp loss, rolling resistance, and wind resistance, with less time in the miles traveled.

Many trucks on the road today cannot operate on the level with the rated gross-combination-weight at a legal speed. Therefore, with these high hp engines, we will be spending less time in the lower ratios and moving that saved time into the upper ranges of the transmission. Although the actual time spent in low speeds of the transmission will be less, the life hours may be decreased, due to greater hp and speed of the engine. The higher speeds in the transmission, however, will be called on to do more work at greater velocities. So those gears may have to be given attention to give satisfactory life. In operating at these higher speeds, not only do loads on the gears increase but dynamic forces also become greater. This will dictate better design and manufacture of the component parts of the transmission. However, with the high numerical ratios that will no doubt be in the axle with these high-speed engines, some of the maximum ratios we have used in the past may well give way to higher ratios with closer spacing.

When trying to evaluate the axle under these conditions, we find that it must deliver all the hp transmitted to it through the pinion at all times. The transmission, on the other hand, delivers a large per cent of operating hp in direct where the geared speeds are in neutral under no load other than dynamic forces.

This analysis is based on not using overdrive transmissions with these high-speed engines, due to the excessive propeller-shaft speeds, which would necessitate even lower axle reductions. Even with direct-drive transmissions, it still would be necessary to have high numerical ratios in a single-reduction axle. This would mean fewer pinion teeth or substantially larger ring gears, with resulting larger banjo diameters in the axle housings. Therefore, economy would dictate use of smaller pinions. These smaller pinions would have decreased velocity factor, but this probably would be offset by the in-

crease in speed and hp transmitted. This would accelerate wiping action with fewer teeth to take it. Also the dynamic forces from the drive line would be greater on the pinion at these high speeds.

In view of this need to have high numerical ratios in the axles, we could give consideration to some form of double reduction, such as a final spur- or helical-gear combination. Or a planetary means could be used at the differential or in the wheel ends. In that case the axle shaft life would be further enhanced. All of this will lend itself to using a combination of hypoids or spirals to the best advantage. It would also lend itself to using the smallest diameter banjo in the axle housings.

The obvious result with these engines of higher speed and hp is that it will be possible to sustain higher vehicle mph. Therefore, the net answer is that the drive-line units will be doing more work in less time per mile traveled. The average operator is going to continue to want satisfactory life for his truck on the mileage basis, and it is going to be difficult, in most cases, to depart from that yardstick. Therefore, to maintain that standard of performance, it will be necessary to continue the research for better steels, heat-treatments, manufacturing processes, lubricating oils, and design to meet these requirements.

A. F. Stamm

Chrysler Corp.

CERTAIN parts of the author's paper are based upon power requirements calculated according to the conservative SAE Truck-Ability Prediction Procedure. While it is agreed that the SAE method tends to overestimate the power requirements, the author arrives at a need for 190 hp at 50 mph where the procedure, if applied as intended, would come out at about 169 hp. The discrepency seems to come about by applying the friction horsepower equation to the total combination weight, where it is specifically limited to the rated capacity of the power unit only. The gross weight to apply is that of the tractor only.

In regard to the clutch, it is perfectly true that the engine speed and the resulting peripheral pressure-plate velocity place definite limits on clutch diameter. At present, the clutch disc appears to be at least as good as the pressure plate. But, if higher speeds can be assumed to include a definite possibility of increased temperatures at the operating surfaces, it may well be that considerations of the facing material and disc configuration will become more critical. Furthermore, a very important point is brought out in calling attention to the relation between transmission shifting and clutch inertia. Higher speeds are going to be tougher on synchronizers.

For some time now, the propeller shaft has been on the verge of trouble. Even with some engines in current use, the problem of providing safe shafts for overdrive transmissions is not easily solved. Thin-wall tubes are featured today, but they offer very little help in raising the critical speed. Larger diameter tubes are very difficult to handle and do not appear to be a good answer for very much higher speed. Length and diameter limits are currently used. The difficulty and importance of close balance control cannot be stressed too severely. The increased magnitude of disturbing forces and the multiple modes of critical response, which are a penalty of high speed, dictate that joint angularity must approach zero and flange alignment must be nearly perfect. An ideal multiple-shaft installation should produce very little reaction at the center bearings. Nevertheless, bearing mountings of low-vibration transmission characteristics, which are free from resonant periods within the operating speed range, are important today and will be even more difficult to design for still higher speed.

As the number of engine cylinders increases and stroke decreases, a powerplant more closely approaches the performance of a turbine, which is characterized by high speed and low torque. If a suitable turbine were available today, it would almost certainly be equipped with a reduction gear. It also appears to be a logical prediction to conclude that reciprocating engines for heavy-duty trucks that operate and peak at over 5000 rpm will also need reduction boxes. Contrary to the author's contention, the only way to get around extremely high speeds at the power source is to reduce them before they get to the clutch.

With this approach the drive-line problems of the clutch, transmission, propeller shaft, and rear axle would remain about as they are today and capacity would increase only as operators insist upon greater performance, meaning more horsepower.

Whether our source of power operates at 3000 or 30,000 rpm, the road wheels will still be geared to cover a range from about 0 to 60 mph. The problem remains one of matching the source to the load over the necessary speed range.

That an initial reduction in the powerplant is practical follows directly from the author's own data on gear efficiency, and indirectly from cautions about the effect of high speed on safe lubricant levels and increased operating temperature. The most feasible place to provide the special lubrication and cooling necessary for high-speed gearing is in direct connection with the engine, its oiling, and its cooling system.

Author's Closure To Discussion

MR. STAMM differs from the writer only in terms on the 190-hp engine to pull 55,000 lb at 50 mph. He gets 169 flywheel hp, whereas my figure was 190, bare engine. These two figures are quite in line.

The proposed modified SAE calculations are quite urgently needed, since common experience shows the present factors are too conservative.

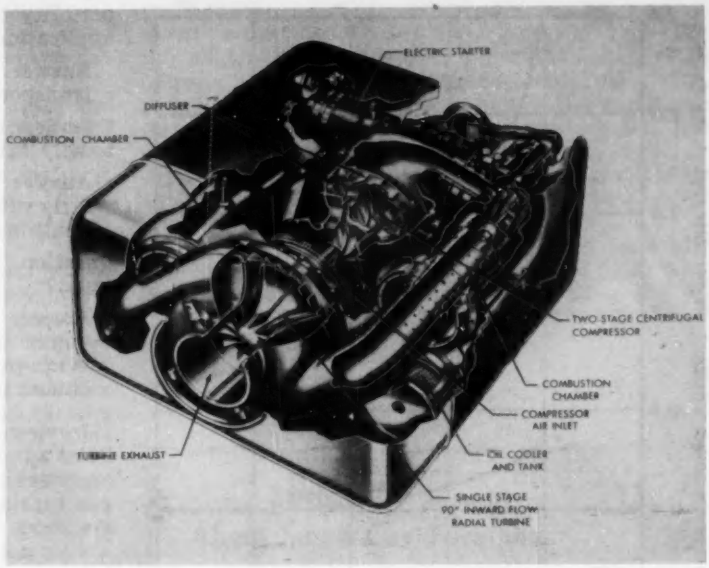
On the subject of reducing the drive-line speed, either ahead of the clutch or in the transmission, it must be agreed that such a step may become mandatory if engines go to the ultimate speeds predicted. Avoidance of overdrive is really a move in that direction. Further moves will, doubtless, be dictated by the degree of speed-up of engines and by economics.

Higher horsepowers, now or in the future, can simplify the transmission. Power/weight ratios in trucks can approach those of passenger cars, with resultant elimination of multiple gear steps.

Most owners will, however, still be conscious of fuel costs. This will place a limit on any extreme increase in horsepower in highway engines.

Small gas turbines are landing many a prime mover job today, thanks to their light weight.

The air-transportable jet-engine starter shown at right is just one of many ways small turbines are getting the nod as . . .



Teapot Tempests Come of Age

Homer J. Wood,

Consulting Engineer (formerly Assistant Chief Engineer, AiResearch Mfg. Co.)

Based on paper "Has the Teapot Tempest Come of Age?" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1953.

SMALL gas turbines (50 to 500 hp) still can't push piston engines out of many of their jobs, but they've got what it takes to cop some of them. Turbines have, for example, won many posts as aircraft auxiliary powerplants. And they're a serious contender for any other powerplant "positions" where weight reduction is important.

Put another way, if it takes more than a 4-cyl engine to do the job, the turbine may be competitive; if four cylinders or less are good enough, the turbine can't compete. What's more, it won't be able to for a long time.

To some extent, small gas turbines have created their own market rather than replaced piston engines in existing fields. And it seems probable that the next few years will bring about a gradual expansion in this direction. There won't be a general encroachment upon major piston-engine markets in the near future.

The past seven or eight years have seen a great deal of activity in the field of small gas turbines (below 500 hp). And, from time to time, the proponents thereof have proclaimed the forthcoming obsolescence of piston engines in this size class.

Yet some difference of opinion must be involved, since major automotive companies continue to invest many millions of dollars in tooling for new engines which they say will be in use for 10 years.

This would indicate that the men who control these companies are not convinced that the "teapot tempest" has come of age in the automotive field. In fact, there are people in the gas turbine business who argue that sound and practical applications of small gas turbines are still several years away and, indeed, may never come to pass.

The author hopes to make some contribution toward resolving this controversy.

Those who would condemn small gas turbines have some valid arguments.

In the first place, the best fuel consumptions

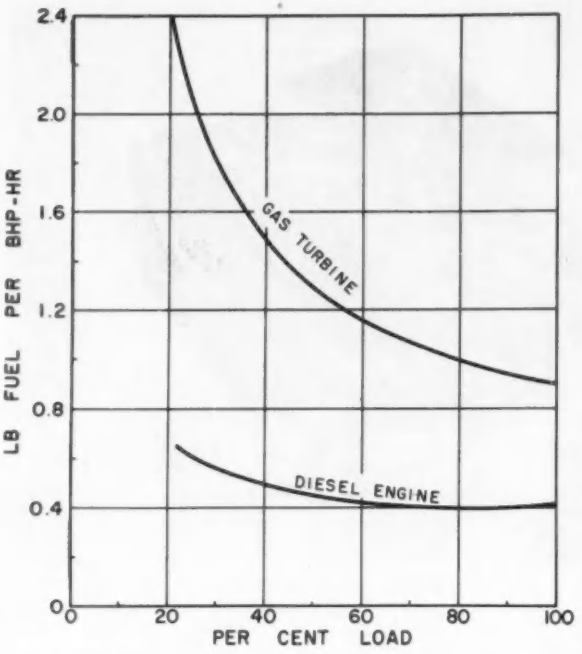


Fig. 1—A small gas turbine tends to consume three to four times as much fuel at 25% load as a reciprocating engine

achieved by small turbines today are about 50% higher than would be considered high for reciprocating engines. And this is only part of the story. Most piston engines are capable of maintaining reasonably good fuel economy down to and below 25% load. A gas turbine, on the other hand, tends to consume three to four times as much fuel as a reciprocating engine at similar loads. (See Fig. 1.)

Furthermore, gas-turbine engines tend to lose their much-vaunted simplicity or to operate at unfavorable stresses or temperatures when they seek to better their fuel economy. Thus, unless some revolution occurs, the temperature and stress limitations of known materials will leave the small gas turbine in an unfavorable fuel-consumption position for quite some time to come.

Perhaps the answers to a few other questions about small gas turbines as they exist today would be revealing:

Question: Are the turbines cheaper in initial cost than present-day piston engines of equal power?

Answer: No!

Question: Have gas turbines been proved to be more reliable under field conditions than piston engines?

Answer: No!

Question: Have gas-turbine maintenance costs been proved to be lower under field conditions?

Answer: No!

Question: Is there any category of gas-turbine superiority that has been demonstrated by practical application?

Answer: Yes, low specific weight. This favors transportability.

Question: Are there any operating conditions which clearly favor gas turbines?

Answer: Yes, low temperature operation, particularly with respect to starting without preliminary heating.

Question: Do gas turbines have installation advantages?

Answer: Yes, in so far as space required per horsepower is concerned. This is particularly true when piston-engine cooling requirements are included in the comparison.

In view of the number of unfavorable characteristics admitted above, it would seem that the writer exercises considerable temerity in stating that small gas turbines have proved themselves to be useful members of the prime mover society.

This position is taken because of the overwhelming importance of low weight for certain applications. To be more specific, the small gas turbine has come of age as an aircraft auxiliary powerplant where the auxiliary service is primarily for (1) making the airplane self-contained by providing power on the ground when the main engines are inoperative, or (2) for relatively short portions of the flight plan which render fuel consumption of secondary importance.

In such applications, no other form of prime mover can reasonably be substituted—even though life and reliability of small turbines needs to be improved.

The same bold statement is not necessarily as secure with respect to air-transportable ground equipment. For such applications as external-store streamlined pods, there can be no doubt that piston engines are quite undesirable.

However, for equipment that is designed to be transported in cargo aircraft, it can be argued that the weight penalties of piston engines may be accepted.

It is the writer's firm opinion that this is a transitory matter. Why? Because of rapid developments that are coming as a result of field experience. These will soon put gas turbines into a class of life and reliability that will make them unquestionably superior to piston engines for ground equipment that must be air transported.

Laboratory endurance tests have demonstrated, for example, that overhaul life between 500 and 1000 hr is well within grasp, provided the machines are not subject to misuse or abuse.

It may be argued that a 500 to 1000-hr period is not enough (to which we reply that this is not an upper limit). But, somewhere between 1000 and 2000 hr of overhaul life, we would have to start thinking in terms of increasing specific weight substantially.

Actually, when it comes right down to it, there are relatively few lightweight piston engines whose overhaul life exceeds 1000 hr.

What's more, it is felt that within three years, small gas turbines will have the same service life

and reliability as piston engines weighing two to three times as much.

The matter of cost must, of course, enter the picture.

Here again, we believe that in three years the turbine will be able to compete costwise with the piston engine in equal production quantities. However, turbines will be unable to compete in first cost with piston engines that represent conversions from fields of large production where, for various reasons, the gas turbine is not suitable.

In discussing this question of cost, it should be noted that the number of cylinders in the competing piston engine plays a major role.

In the aircraft propulsion field, piston engines equivalent to gas turbines must have upwards of 24 cylinders, and the resulting engines are complex and costly. On the other hand, in the 500 hp and below market we find anywhere from 1 to 12 cylinders.

And while small gas turbines tend to be simpler than their large relatives (jet engines), the degree of simplification is nowhere near as great as it is between large and small piston engines.

Thus, this generalization seems reasonable: Wherever four cylinders or fewer are good enough to do the job, it will be a long time before a gas turbine can compete. From four cylinders up, increasing piston-engine complication gives the gas turbine a chance to offer competition in the not-too-distant future.

Noise level frequently has been cited as a disadvantage of the gas turbine. Actually, however, a completely unmuffled piston engine of the same rating as a gas turbine would have approximately the same total noise level, though in different frequency ranges.

The problem with a gas turbine is to provide muffling without excessive intake and exhaust pressure losses. The feasibility of providing such muffling has been demonstrated, but the sacrifices in weight and bulk are noticeable. Even so, a substantial weight advantage exists in favor of the turbine.

Now, what about the future?

It is felt that the first three questions raised earlier in this article aren't always going to be answered in the negative. With time, these answers are going to pass through a "maybe" stage . . . and finally into affirmative answers through normal operation of the "learning curve."

As for the evolutionary trend of small gas turbines, it is toward simplicity, reliability, and adaptability—with fuel consumption and frontal area being of secondary importance. It is not felt that the possible improvements in fuel consumption that could be achieved with more complexity would offset the increased cost and reduced reliability necessarily implied.

This does not mean that fuel consumption reduction is being ignored. The distinction is that we do not believe that the complications necessary in large gas turbines to achieve this end can be justified in small machines.

In summary, the writer believes the small gas turbine is here to stay as a prime mover. It has already demonstrated its basic suitability for aircraft auxiliary power. And it will shortly prove a serious contender in all fields where weight reduction of the prime mover is important (the extent of such fields is not yet fully explored). However, it is likely to be many years before the small gas turbine seriously invades those markets where low weight is not an important consideration.

To venture a prediction, propulsion of small helicopters looks like the next field where the "teapot tempest" will come of age.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Service Lessons Learned About Small Gas Turbines

Knowledge gained from field service experience with small gas turbines has been invaluable to turbine design engineers. For example, it was learned that:

- At least for a few years, the fuel/air ratio or, more exactly, gas temperatures, must be kept carefully within bounds. Otherwise, the machine will have a very short life.

- Speed and temperature controls must be effective in the face of misuse or abuse, especially during starting.

- Control objective should be to hold the turbine, under starting conditions, to the temperature limits that correspond to maximum output of the machine at full speed.

- Automaticity is a must (where required automaticity is defined as the minimum which permits faulty control manipulation by the operator without damage to the machine).

- Allowance must be made for as many as 10 starts per hour of operation.

- Future small gas turbines should either have single combustors or cross-firing multiple combustors.

- "Packaging" turbines to minimize sensitivity to installation is a very sound practice.

How-Best-to-Do-It

In This Article . . .

THIS ARTICLE is full of "how-best-to-do-it" ideas and data on current plant layout and plant engineering problems. Those problems are varied and complex . . . and the aircraft industry has a few special ones, in addition to sharing many with other automotive plants.

Two basic problems are: how best to use existing facilities and how to plan new facilities. And growing out of them is the constant need to gear organizations to committed programs while at the same time moving toward the best *ultimate* use of space. Then, come the more specific problems . . . how best to make plant layouts reflect the visual controlled flow of materials through men and machines . . . application of the best techniques for actually making the layouts . . . and how to judge the effectiveness of a layout after it is made.

Closely allied to these plant layout questions is: "What can we do to improve and reduce general maintenance?"

This article is an abstract of the secretary's report. . . . The full text of this report, along with that of the secretaries' reports of the other nine panels at this Production Forum is available from SAE Special Publications Department, 29 West 39 St., New York 18, N. Y. as SP-304. Price: $2.00 to members; $4.00 to nonmembers.

Meeting 2 Basic Problems

The two basic problems of plant engineering and layout in today's aircraft industry are:

(1) Utilization of existing facilities, and
(2) Planning new facilities

Economic utilization of existing facilities usually poses the more complex of the two problems. More factors have to be weighed and resolved to get optimum economy. Take power limitations, for example. When power requirements go beyond existing capacity, the question has to be answered: "Shall we, or shall we not, convert to a higher capacity system?" And the right answer depends both on immediate cost and potential amortization.

Every plant utility, piece of equipment, building and surrounding area, in short, have to be weighed as to cost of improvement and rehabilitation as compared to cost of maintenance. Sometimes spreading plant equipment will raise costs; sometimes confining it will raise costs.

In any case, production gains made by bypassing proper preplanning usually are insignificant when weighed against total costs involved. Management should always be given a complete analysis of the dollars and cents effect of prior architectural design vs. no prior architectural design. And it is practically a "must" that *new* facilities be designed for a specific requirement.

Simultaneous Solutions Needed

Gearing an organization to committed programs and, at the same time, moving toward the best ultimate use of available area is a perpetual challenge to plant engineers and layout groups.

Getting ultimate space utilization economically, involves:

(1) Use of additional shifts and overtime when necessary to absorb short-duration peaks in production. (This helps to avoid employment peaks and valleys.)

Methods . . .

. . . for plant engineers and plant layout crews

J. A. Maurice, North American Aviation, Inc.

Based on secretary's report of Panel on Plant Layout and Plant Engineering held as part of the SAE Production Forum at the SAE National Aeronautic Meeting, Los Angeles, Sept. 30, 1953.

(2) Conscientious use of methods techniques. (For example, duplicate tooling can sometimes be removed, the line flow shortened and the costs reduced.)

(3) Careful analysis may show how subassembly work can be removed from large jigs. (Potentially, this cuts the number of large jigs required. But it also permits specialization of worker assignments and aids in optimum crew placement.)

(4) Installing minimum of jigs and fixtures at the beginning of a contract when schedules are slow. (Duplicate tools can then be strategically placed as experience is gained.)

(5) Setting assembly departments up as flexibly as possible to compensate for changes in production requirements. (This can be done by using pickup line areas for tooling construction. . . And further thought can be given to strategic intermixing of small tools in large key-jig areas.)

Layout Must Reflect Flow

Successful plant layout must reflect the visual controlled flow of materials through men and machines. It demands the interweaving of men, materals, and machines. It requires proper placement of secondary factors, supporting items—like tool and parts cribs, supply racks, office areas, indirect areas for supporting functions, toilets, aisles, etc.

Success in any given layout depends on two related phases of operation: (1) a concerted and continuous selling program throughout the organization, and (2) maintenance and improvement of the installed layout . . . day-after-day and month-after-month.

Contrary to the belief of many, the area needed for an efficient layout isn't bigger than that needed for an inefficient one. If, at the outset, adequate area is provided, practice of good layout principles brings no penalties.

Application of the basic principle of visual flow of material through men and machines does, of course, have to be applied to start with. Improper emphasis on the secondary items must be avoided.

Getting line supervision to accept these basic principles of efficient layout is a continuing, major problem. The selling program must be carried on continuously with the man on the floor. Plant layout and plant engineering personnel have to do this in their day-to-day dealings. But the selling program must be one of singular principle, purpose, and definition.

Some have had most success by starting to get plant layout approvals from the lower levels of supervisory authority—assistant foremen, foremen, general foremen, superintendents, etc. Others have been successful by starting at the works manager and factory manager level.

The "from-the-bottom-up" proponents feel their method is best "to integrate all affected supervisory levels and insure the highest possible percentage of acceptance." The "from-the-top-down" proponents emphasize that this approach doesn't mean that shop supervision is compelled to buy the layout

Plant Layout and Plant Engineering Panel Members . . .

H. W. Linton, Panel Leader
North American Aviation, Inc.

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Consolidated Vultee Aircraft Corp.

C. H. Brubaker
Hughes Aircraft Co.

V. N. Ferguson
Temco Aircraft Corp.

J. P. McNamara
North American Aviation, Inc.

A. G. Hamilton
Republic Aviation Corp.

because higher levels have approved. It is just a means through line organization of overcoming arbitrary opposition to good layout practices.

Everywhere, it seems to be agreed, the return of layout dollars to the company in terms of savings is and must remain a ruling factor in planning, executing, selling, activating, and maintaining plant layouts.

3 ways to Make Plant Layouts

At least three different techniques for achieving plant layouts are in use today to greater or lesser extents.

- Templates pinned to a layout board with map tacks, it is said, are in industry-wide use.
- The photographic method is being thought of as a potential means of standardizing plant layout techniques—and offers a way to reduce tedious and costly aspects of drawn layouts and of the template and map-tack technique.
- Three-dimensional layouts, it seems, have been exploited recently by many companies to a greater or lesser degree—and have been subjected to some noteworthy developments in the last year or so.

The relative newness of the three-dimensional technique made it a center of discussion, following brief descriptions of the two better-known methods.

Many companies in the East, it was brought out, are making and selling 3-D models—are aiming definitely toward standardization and classification of models.

What are now classified as "A" models are those which are manufactured with great attention to detail. They cost about $10 each for the average machine or piece of equipment. And they can be bought from their producer's shelf stock. ("A" models of large pieces may go as high as $20 each.)

Class B models differ only in that less attention is paid to detail in making them. They run about $5 apiece from shelf stock.

3-D models of facilities are also available in the East. They sell for an average of 6¢ per thousand square feet of actual plant area. They contain great detail, including utilities layouts, lighting systems, sprinkler systems, blank columns, mezzanines, stock cribs, offices, etc.

Big advantage of 3-D layouts, it was said, is that they are easily understood and easily read as compared to the two flat types of layout. And they usually make possible development of new layouts in minimum time. They are easy for everybody from top management through all levels of supervision.

Big disadvantage mentioned was cost. Some said, too, that keeping 3-D layouts free from dust is a problem. Also, maintaining changes in tooling and product virtually demands setting up an on-site model shop properly equipped to maintain such changes. Since the 3-D layouts are so easy to read, one engineer suggested, they make it easy for everybody to become a layout expert, whether qualified or not. "Criticism of well-planned layouts is not uncommon," he said.

Whether the extra detail of the Class A model is worth the money depends on the individual case, it seems generally agreed.

Checking Layout Effectiveness

Three ways to measure layout effectiveness for overall aircraft plant operation were suggested:

(1) Ratio of area to direct worker.
(2) Ratio of airframe pounds produced per square foot of floor space.
(3) Dollar output per square foot of floor space.

Some have established other more finite measurements for specific areas of manufacture in the fabrication and processing, major and final assembly, stocking and warehouse areas. These were said to be:

(1) Use of the cube.
(2) Zone station evaluation.
(3) Dollar investment per square foot.

Any method of measuring plant layout effectiveness, it was said, depends on establishment of a base to which all other factors can be associated.

How to Cut Maintenance

Answers to the question "What can we do to improve and reduce general maintenance in the aircraft industry?" netted five specific suggestions:

(1) Provide a well planned and organized maintenance operation;
(2) Provide adequate maintenance facilities properly located within the plant;
(3) Provide a well-staffed organization;
(4) Have a positive objective;
(5) Do what is necessary to insure that the maintenance program is accepted and supported by all other activities in the company.

A well-planned operation will begin in the early planning stages of the facilities, equipment, and

plant layout programs. It will include specifically assigned responsibilities supported by adequate supervision. It might be built around craft responsibilities, with a foreman supervising each craft group. Basic responsibility would be at each supervisory level. . . And the supervisor would get a chance to check plans during their preparation or at completion. He would be responsible, also, for accepting work from outside contractors.

This well-planned operation might also have a work-control section . . . a service group to absorb paper-work burdens from supervisors. It could be responsible for maintenance stores, equipment, lubrication records, all supporting clerical functions, etc.

A technical engineering staff, reporting to the chief engineer, could further support such a well-planned operation. This staff would prepare maintenance procedures, inspection programs, work on all technical aspects of maintenance, and provide a consulting service for maintenance supervisors.

Some think this well-planned maintenance operation could be best if combined with plant construction functions. Others think the two functions could best be performed separately.

Factory maintenance and repair costs may vary, it was reported, from 0.5 to 20% or more of a company's total gross sales in dollars. The national industry average is about 4.35% . . . and in the aircraft industry, about 3%.

In an aircraft plant, it is estimated, about 75% of all maintenance effort (under a well-planned program, may be on routine, continuous-type maintenance; 10% on long-term maintenance; and the remaining 15% on breakdown maintenance. It is estimated, too, that rearrangement work in the aircraft industry absorbs about 20% of its total maintenance effort. Continuous changes and developments inherent in this industry peg this factor as a relative constant.

Ride and Vibration Instruments . . .

. . . need more versatile, lighter, and easier-to-install power sources for on-the-road testing, experts at Summer Meeting round table report.

Based on Report by **B. E. O'Connor,** Houdaille-Hershey Corp.

SUPPLYING each ride and vibration instrument used in on-the-road tests with proper current, voltage, frequency, and suitable regulation isn't easy.

The short-order program, wherein a car must be instrumented, tested, and returned in a few days, presents the most difficult power-supply problem. But even where test time is not limited, the problem isn't an easy one to solve.

Best proof of this is that all of the following power sources have been tried—and all of them are seldom entirely satisfactory: batteries, battery-powered motor-generators, battery-powered electronic and vibrator-type inverters, auxiliary engine-driven generators, and automobile engine-driven generators.

What's really needed are power sources that can meet all of these requirements:

1. **Capacity and Regulation**—Capacities should range from 100 to 5000 w for duties up to 8 hr. There should be suitable voltage and frequency regulation from full load to fractional load in the presence of moderate mechanical shock, varying ambient temperature and humidity, and rapidly varying loads.
2. **Size and Weight**—Since test personnel and equipment must be packed into the limited space of an auto, the power source should be small. It should also be light. The latter is especially important when measuring car performance or other phenomena that are a function of vehicle load.
3. **Noise and Vibration**—Noise and vibration levels produced by the power supply should be well below those of the car. Also, the power source should not create an electrical field that can be sensed by the instrumentation, masking the information recorded.
4. **Adaptability**—The power source should be capable of supplying more than one voltage and frequency. Reason for this is that instruments having different power-supply requirements are used simultaneously. (This requirement can be eased by further standardizing the voltage and frequency of ride and vibration instrumentation.)
5. **Installation**—The power source should be easy to install. Limited preparation time makes the installation of special pulleys, belts, and generators on the engine undesirable. A power supply that could operate from the car battery and generator would be ideal in many cases.
6. **Servicing**—Many who employ ride and vibration instrumentation are not proficient in maintenance. Thus, power supplies must be dependable . . . and easily serviced with readily available components.

This information on automotive ride and vibration instrumentation was brought out at a 1953 Summer Meeting Round Table on Instrumentation and Evaluation of Riding Comfort. Leader of this Round Table was A. C. Bodeau, of Ford. Panel members were D. C. Apps, GM Proving Ground; R. D. Evans, Goodyear; M. P. Hershey, Firestone; N. E. March, Chrysler; A. K. Simons, Bostrom; F. R. Kishline, Nash; W. A. McConnell, Ford; R. O. Williams, Packard; L. L. Helterline, Sorensen; G. G. Ross, General Radio Co.; T. E. Stewart, Electro-Mechanical Research, Inc.; J. J. McDonald, Consolidated Engineering; J. D. Rogers, du Pont; A. D. Pendleton, Brush Electronics; and W. G. Pierce, A. O. Smith.

AIRCRAFT TOOLING

PRODUCTION men in aircraft plants face a two-way squeeze and tooling men find themselves right in the middle of it.

Designs coming out of engineering call for more complicated machines with increasingly tighter tolerances. Yet management's demanding that shop costs be held down.

Tooling for new production techniques has helped production meet this crossfire of demands. This article tells how this is being done in the airframe industry. It's drawn from discussion led by the following panel:

Panel Leader
C. S. Glasgow
Douglas Aircraft Co., Inc.

Panel Co-Leader
S. N. Bean
Lockheed Aircraft Corp., California Division

Panel Secretary
K. H. Boucher
Douglas Aircraft Co., Inc.

Panel Members
G. A. Evans
Glenn L. Martin Co.

R. A. Fuhrer
Consolidated Vultee Aircraft Corp.

A. L. Hilleland
Willys Motors, Inc.

J. S. Semprez
Douglas Aircraft Co., Inc.

B. D. Shepherd
North American Aviation, Inc.

TOOLING costs for today's airplanes are bound to be higher than they were 10 and 20 years ago. Jet planes are more finicky about aerodynamic tolerances and embody more complex structural parts.

Even though he has no control over these factors, the tooling engineer can help bring down tooling costs by working with design engineers and manufacturing men on plane breakdowns, tooling programs, scheduling, and production rates.

1. AERODYNAMICS AND TOOL COSTS

Tighter CAA regulations and increased plane speeds have swelled tooling costs. Higher quality aerodynamic surfaces have been largely responsible.

For example, a 1939 model airplane called for virtually no aerodynamic checks. The parts were of simple sheet metal. Whatever the tools produced, that's what was installed. Flat head rivets were used only on the wing leading edge, horizontal stabilizer, and vertical stabilizer leading edge. All others were brazier head rivets. Lap joints were used on all skins.

A 1950 model design contains all flush rivets, flush joints, and the quality of aerodynamic surfaces is checked with splines.

Engineering departments are imposing increasingly tougher tolerances today. In one case, the original waviness requirement was 0.015 in 6 in. It is now 0.005 on the wing leading edge to trailing edge of control surfaces. Tolerances on gaps, flush joints, and openings are being reduced on a new model to 0.030 in. maximum where there is a seal underneath, and to 0.010 maximum where air can pass through. The maximum allowable mismatch on surfaces is to be 0.008 to 0.012 in.

Tolerances such as these have introduced different forming techniques and such things as contour boards on assembly jigs, which have increased the cost of tooling.

Finds Jet Age A Challenge

K. H. Boucher, Douglas Aircraft Co., Inc.

Based on secretary's report on Economics of Tooling Panel held as part of the Production Forum at the SAE National Aeronautic Meeting, Los Angeles, Sept. 30, 1953.

To produce such higher quality airplanes economically, the following are recommended:

1. Get engineering, production, tooling, and inspection together early in the airplane design to agree on requirements and mutually understand each other's problems.

2. Convince engineering to allow more liberal requirements where tolerances aren't critical.

3. Properly inform all concerned of all needed tolerances, preferably by written communication.

4. Continue research and development to find better and cheaper production methods.

5. Tool at a minimum cost to meet requirements. Don't build a tool which you later find out is inadequate and has to be rebuilt.

2. EFFECT OF AIRPLANE STRUCTURE

The ordinary safety razor blade is similar in proportions to the 3½% wing on high-speed jet airplanes. Such thinner wing chords are another reason why tooling costs are higher.

Structures today are made of thicker and different material. Fig. 1 compares the tail assembly for the 1938-designed P-51 with that of a modern jet. The first, made of 24S aluminum, took 200 hr to tool. It required 2800 hr for tooling the modern titanium assembly.

Use of new materials like titanium and thicker aluminum sheet create tougher tooling problems. Drilling, holding, and trimming operations are tougher; they require heavier fixtures, machinery, and special hand tools. Airfeed type drills have become necessary for drilling rivet and bolt holes through skins.

Lockheed is using integrally stiffened skins on one model, and estimates it costs two to three times more than normal construction. But the integral structure weighs 350 lb less than the conventional one, including sealing compound. The original skins were hot formed in the power brake, but now are being shot peened to contour. Because the integral skin consists of fewer parts, it produces savings all along the line . . . in production control costs, shop follow-up, inventory costs, and storage.

Bonding has emerged as another effective technique. Consolidated Vultee found bonded metal surfaces have better fatigue life than riveted ones. And they get aerodynamically smoother surfaces with bonding, too. It costs slightly more, but Con-

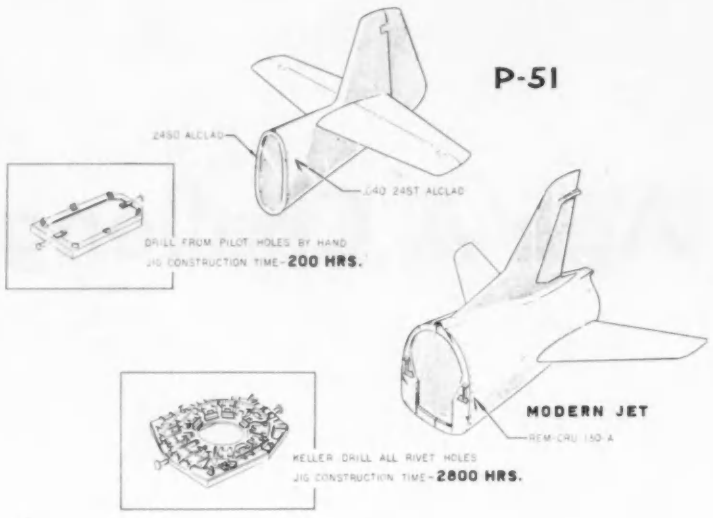


Fig. 1—It took 14 times as long to build tooling for the modern jet assembly shown at left as for its 1938 model counterpart

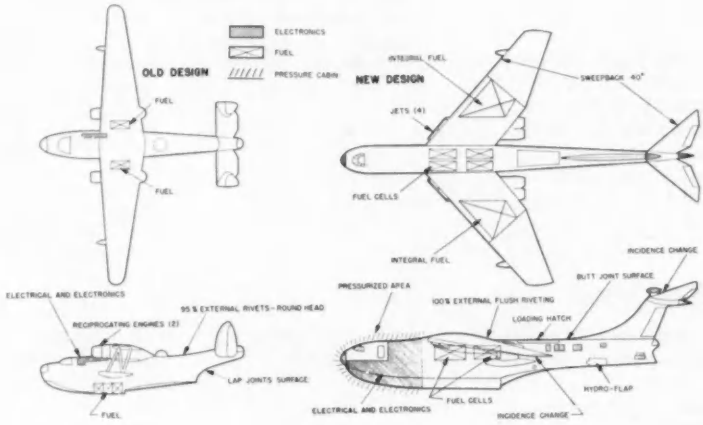


Fig. 2—The added complexity of modern aircraft plus higher speeds demand different joints and airplane breakdown than called for by older designs. This is shown by the sketches at right

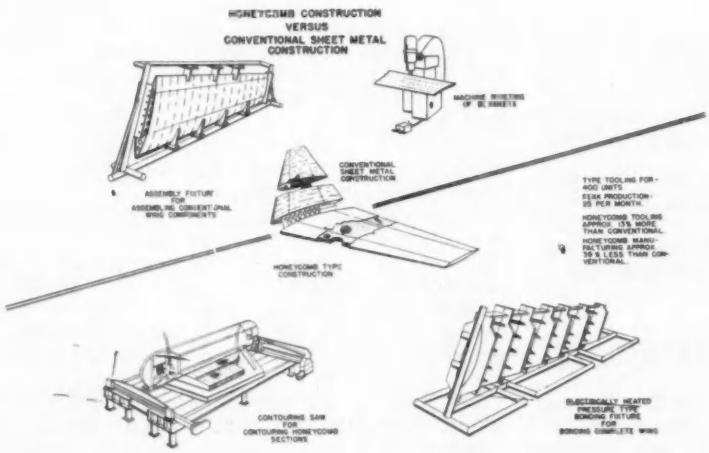


Fig. 3—Tooling for a honeycomb wing costs 13% more than that for a conventional wing; but it costs 39% less to manufacture the honeycomb wing

solidated feels it's justified to meet aerodynamic quality requirements.

Glenn L. Martin is investigating honeycomb inside the structure. Sound and vibration test methods effectively check the bonded structure after fabrication. Unbonded areas can be reheated and made acceptable by applying local pressure.

3. AIRPLANE BREAKDOWN

Tooling departments are deeply concerned over how the airplane is broken down, because this operation heavily influences tooling design. And they want to be in on the airplane breakdown.

Several factors determine the extent of the breakdown, where the breaks should be, and what kind of joints are most suitable. Subcontracting and spares requirements also need consideration. Design requirements—such as doors, hatches, flaps, and ailerons—are pretty well established and are the least controllable. Fig. 2 shows what you get into in the breakdown phase to determine joint types. Today's requirements are different because of more fuel and electronic equipment, radar, and new type constructions.

Although the more complex airplane is boosting production and tooling costs, man hours per pound of plane are more than holding their own. For example, Glenn L. Martin finds that in using honeycomb sandwich construction, tooling cost is up 13%, but manufacturing cost is 39% lower than with conventional construction. See Fig. 3.

Production men generally agree that the airplane breakdown should be made in the preliminary design stage of engineering. It should be the joint responsibility of engineering, tooling, and manufacturing.

4. SCHEDULING

Tight scheduling and peak loads tend to increase tooling costs. Their effects can be minimized by taking the following steps:

1. Make mandatory tools as near the first article as possible.
2. Make nonmandatory tools as cheaply as possible.
3. Borrow people from production.
4. Use three shifts for tool fabrication.
5. Train personnel.
6. Subcontract judiciously with adequate liaison.
7. Properly organize the program (via the project system).
8. Use prototype tools to a greater extent.

Most of these items are controlled by the rate of production, a discussion of which follows.

5. PRODUCTION RATE AND TOOLING

Engineering breakdown and production rate are integrally tied with each other. Fig. 4 shows the difference in breakdown for a three-ship program as against a 400-ship program.

Tooling has to live with many contingencies, even after the production tooling program is launched. For example, the production shop may decide that redesign of a tool may save manufacturing time. If time standards show that the production time saved is greater than the tool redesign and fabrication cost, then the tool should be reworked.

Military services bring another problem. They will order a prototype airplane. But before it is

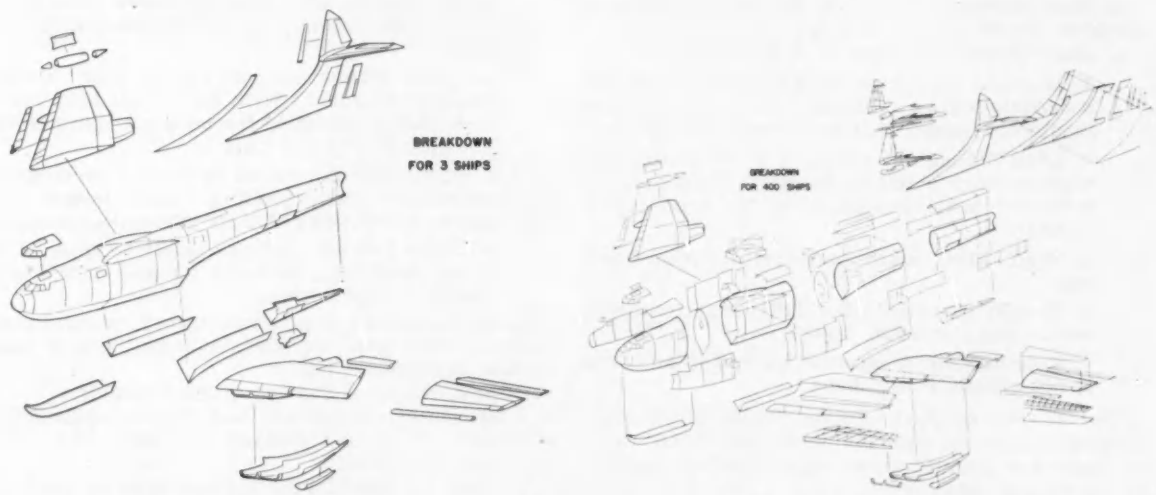


Fig. 4—An airplane breakdown for tooling varies with the production quantity involved. The breakdown for three airplanes (left) is much simpler than that for 400 (right)

completely built, they will order an intermediate number of planes. So tooling has to be started before prototype tooling use can be discontinued.

Some plants have found it helpful to make models of jigs to determine clearances and accessibility. Others have found cases where certain jigs can be usable in both prototype and production programs. One company found it economical to go to an extensive subassembly program after 80 airplanes.

A final tooling consideration is interchangeability. Greater need for spares and manufacture of same airplane or components by several companies intensifies this requirement.

However, tooling men agree that 100% interchangeability should not be made between the prototype and follow-up airplanes. In many instances tooling flow time won't allow for an interchangeable tool available for a prototype airplane. With the need for getting airplanes into the air more quickly, achieving interchangeability can be a costly luxury.

(The report on which this article is based is available in full, together with the secretaries' reports of the other eight panels at this Production Forum, as SP-304 from SAE Special Publications Department, 29 West 39th St., New York 18, N. Y. Price: $2.00 to members, $4.00 to nonmembers.)

Tooling Programs . . .

. . . may fall into one of three types. Each has its pros and cons. But the two-phase tooling program seems least desirable from several angles.

There are three types of production tooling programming. Fig. A compares the economics of the three plans, for a plant doing detail machining.

The first method is called Two-Phase Production Tooling. It involves the construction of two sets of tooling—an interim set and a final production set.

Its advantage lies chiefly in the fact that a few parts can be delivered within six months. Low production is reached shortly thereafter. High production is not reached until the second or third year.

Its disadvantages are:

a. High tooling costs as the result of building a complete set of interim tooling.

b. High production costs as a result of:

1. Inability to use multiple spindles, since the machines will be available, but interim tooling would not include tooling for multiple spindles.

2. Lead time is not adequate to purchase production-engineered die forgings in accordance with the basic ground rules for good sound tooling.

3. High direct labor costs result from small lots.

4. Quality standards are difficult to maintain when using interim tooling.

5. Coordination of interim tooling when there is not adequate lead time.

The second method, Single Phase Production Tooling, takes six months additional lead time. All parts are manufactured on production tooling. Its advantages are:

a. Tooling costs are lowered by 15%. Cost of production tooling is higher than Method I, because there is no previous experience on prototype or interim tooling. However, as a result of a longer time span to build the tools and no cost for interim tools, the total tool cost is less.

b. Lower part cost by 15% because:

1. There is a slower buildup of burden personnel and less total burden is required to maintain high production rate.

2. Additional lead time allows for the procurement of production-engineered die forgings for all parts. No hogouts are necessary which results in a somewhat lower material cost.

3. Quality standards are higher and the scrap rate cost is lower by having good forgings and better tooling, with adequate time allowed to coordinate engineering and production problems.

4. Lower production cost results from use of multiple spindles. With additional lead time, tools can be provided for multiple spindles on the first production part.

5. Setup time is reduced by having production tooling in the beginning. Also, larger lots can be run which result in substantial savings.

6. Organizational savings result because of a longer lead time to build up and coordinate efforts of supervisior.

c. Additional lead time allows time to procure machines. This calls for fewer substitutions of machines on first part run.

Disadvantages of Method II are twofold:

a. Six months additional lead time is required for ship sets. Parts are delayed and delivery to the customer is held up.

b. Basis for establishing the sequence of machining has to be based on general data instead of factual individual part experience.

If it is necessary to furnish parts as soon as possible at reasonable cost and the normal lead time

called for in Method II isn't available, a third program is recommended. It's called the Prototype and Production Tooling Program.

It consists of engineering prototype tooling for about 10 ship sets of parts, to be produced with as low tooling cost as possible. There are five steps in the program: (1) production engineer the part; (2) design tools and release on an individual basis; (3) get hand-forged hogouts; (4) build tools—release them on an individual basis; and (5) tryout tools on an individual basis.

This method has the following advantages:

a. Delivery of parts is possible within several months and accumulative deliveries will reach the same number at the same time as under the other methods. The tool cost is only slightly more than Method II, Single Phase Production Tooling.

b. Tooling for the first 10 ship sets of parts are 15 to 20% cheaper than interim tooling used in Method I. A portion of this saving is the result of a shorter time span of about 25% to build the tools as compared with interim tooling. Overall, the saving in tool cost is about 6%.

c. Part saving of about 10% can be realized because direct labor is greatly reduced by having high production tools available in a shorter time. Direct labor for the first 10 parts is higher, however, as a result of using forged blocks prototype tools.

d. Fast delivery of hand forged material is usually possible.

e. You can establish your sequence of machining for development of high production tooling.

f. You can allow sufficient lead time for tool build.

The cutoff point between a hogged-out parts program and a single purpose program depends on the airplane schedule. However, 10 ships is recommended as minimum. In general, aircraft companies throw away their prototype tools and start from scratch with new production tools. Some redesign assembly structures for production programs.

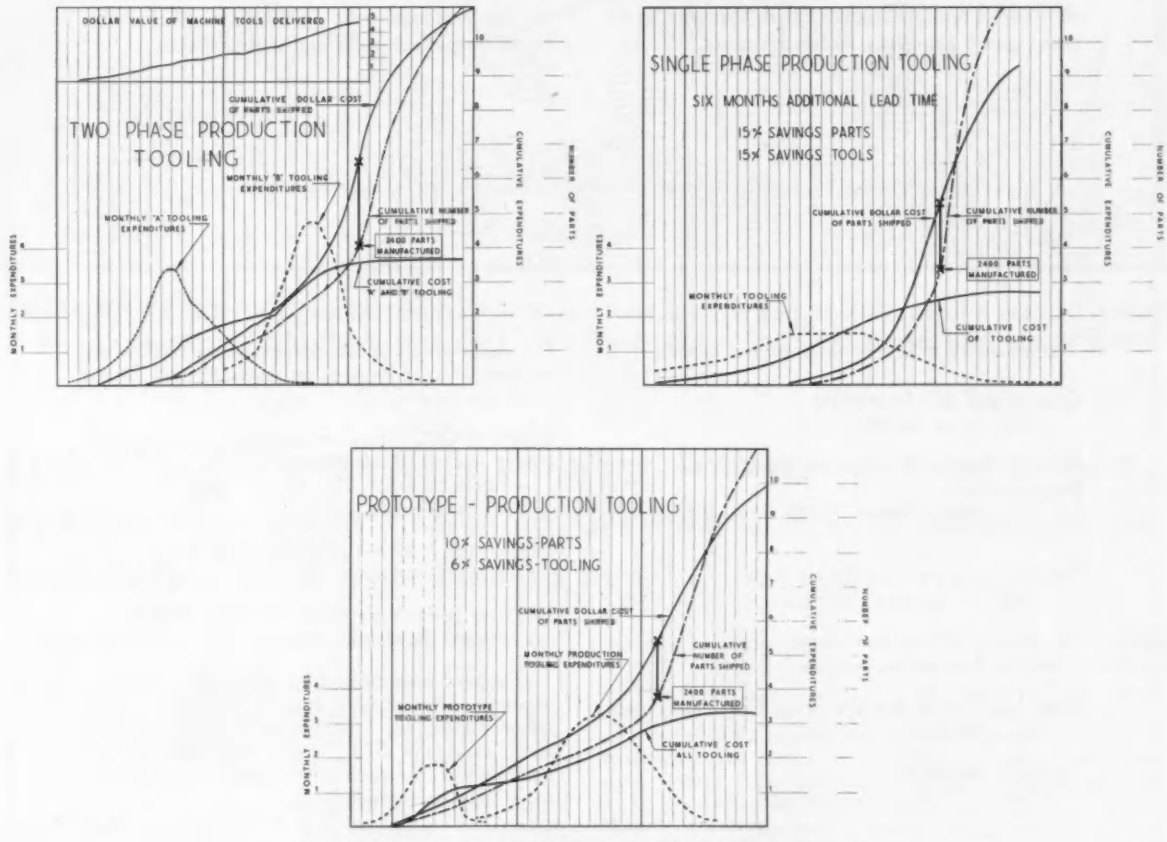

DOLLAR VALUE OF MACHINE TOOLS DELIVERED
TWO PHASE PRODUCTION TOOLING
CUMULATIVE DOLLAR COST OF PARTS SHIPPED
MONTHLY "B" TOOLING EXPENDITURES
MONTHLY "A" TOOLING EXPENDITURES
CUMULATIVE NUMBER OF PARTS SHIPPED
2400 PARTS MANUFACTURED
CUMULATIVE COST "A" AND "B" TOOLING
MONTHLY EXPENDITURES
CUMULATIVE EXPENDITURES
NUMBER OF PARTS
SINGLE PHASE PRODUCTION TOOLING
SIX MONTHS ADDITIONAL LEAD TIME
15% SAVINGS PARTS
15% SAVINGS TOOLS
CUMULATIVE DOLLAR COST OF PARTS SHIPPED
CUMULATIVE NUMBER OF PARTS SHIPPED
2400 PARTS MANUFACTURED
MONTHLY TOOLING EXPENDITURES
CUMULATIVE COST OF TOOLING
PROTOTYPE - PRODUCTION TOOLING
10% SAVINGS-PARTS
6% SAVINGS-TOOLING
CUMULATIVE DOLLAR COST OF PARTS SHIPPED
MONTHLY PRODUCTION TOOLING EXPENDITURES
CUMULATIVE NUMBER OF PARTS SHIPPED
2400 PARTS MANUFACTURED
MONTHLY PROTOTYPE TOOLING EXPENDITURES
CUMULATIVE COST ALL TOOLING

Fig. A—Three types of tooling programs and how they compare in costs. Both the Single Phase and Prototype-Production Tooling methods are more economical than the Two-Phase Production Tooling method

The Arctic Yields To

THREAT of transpolar aerial attack is forcing this country to face and solve the problems of operating aircraft from Arctic bases. Thanks to the military men who are defying the miseries of the Far North and to engineers who are developing cold-weather equipment for them, the problems are shrinking.

The shortest routes for enemy bombers from other Northern-hemisphere continents to our cities lie on Great Circle routes close to the North Pole. Likewise, these are the shortest routes for our own strategic bombing missions to many potential targets. So it behooves us to stand guard along the Arctic frontiers.

Flying over these regions isn't much different from flying over other parts of the earth. But surface operations from cold-plagued land masses and frozen seas are very different from what we're accustomed to in warmer climates. The extreme cold and associated hazards offer a thousand frustrations to the men who struggle to keep planes and ground installations in working order.

But we are developing aids—like the low-temperature lubricants, hot-fuel priming systems, and improved oil-dilution systems described in the box accompanying this article—that make Arctic operation easier and more reliable.

The accompanying article is based on the papers:

Ground and Air Operations
—Col. Bernt Balchen, USAF

The Air Rescue Service—A World-Wide Organization
—Brig.-Gen. Thomas J. Du Bose, Air Rescue Service

The Airplane and the Arctic Pack
—Lt.-Col. Joseph O. Fletcher, USAF

Challenges of Alaskan Maintenance
—Col. Andrew E. Krieger, Jr., USAF

Over the Top of the World by Commercial Air
—Einar Pedersen, Scandinavian Airlines System

Arctic Environment
—Paul A. Siple, Department of the Army

The descriptions of the developments facilitating starting of cold engines on pages 38 and 39 are from the papers:

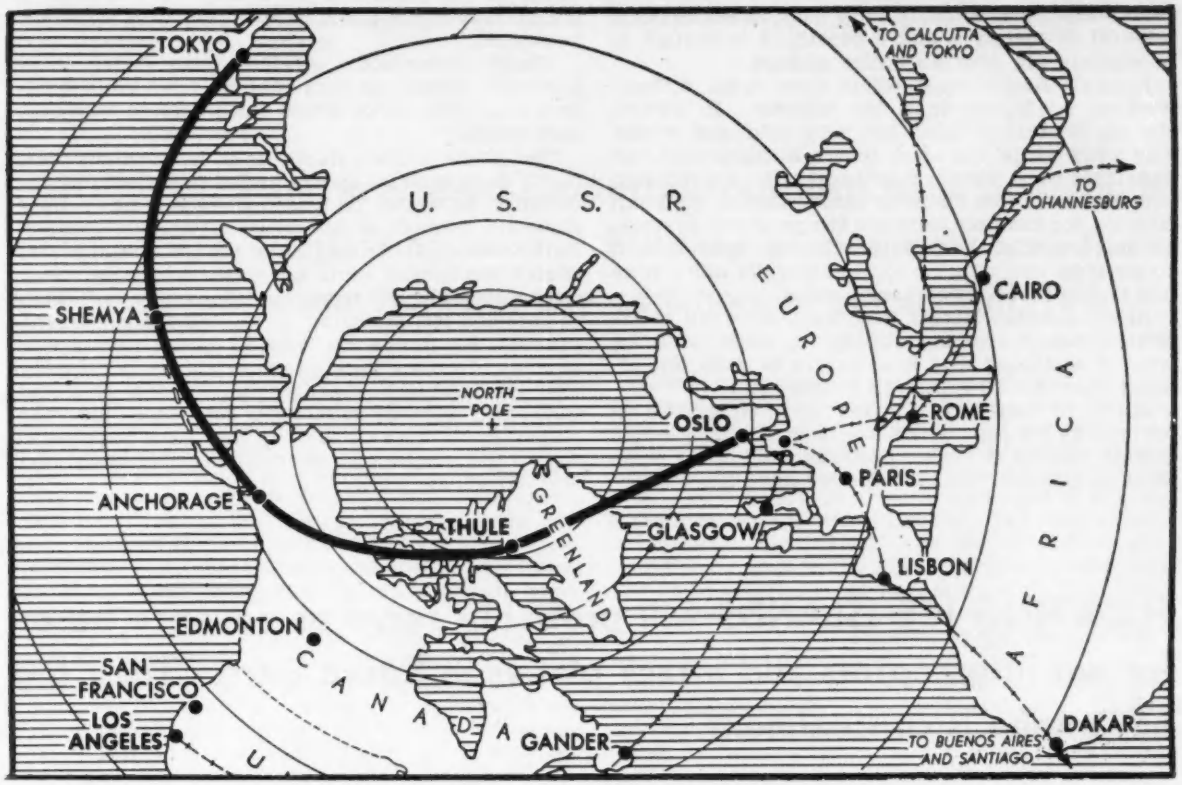
Report of CRC Group on Lubricant Requirements Under Arctic Temperatures
—Kenneth Boldt, Pure Oil Co., and H. C. Mougey, General Motors Corp.

Deaerating Cold Weather Oil Systems
—F. E. Carroll, Jr., United Aircraft Products, Inc.

Hot Fuel Priming for Cold Weather Starting
—Everett Rowland, Wright Air Development Center

The papers were presented at the SAE Summer Meeting, Atlantic City, June 11-12, 1953. Individual papers are available in multilithographed form from the SAE Special Publications Department at 35¢ each copy to members and 60¢ each copy to nonmembers.

The Military Airplane



TRANSPOLAR ROUTES are the shortest between America and Europe-Asia. Route marked is that of an SAS chartered flight flown May 23, 1953. Plane carried Red Cross nurses en route to Korea.

SEVERE COLD is the basic problem all along our string of Arctic installations. From Alaska to Greenland, winter temperatures drop below -80 F from time to time.

Much of the land reaching toward the Arctic Ocean is covered with ice and snow the year round. Where the snow does depart for a month or two, it leaves expanses of rock and lake-strewn plains with only low vegetation. Even the Aleutian Islands don't warm up enough in summer to encourage the growth of trees.

In the great bowl in the center of Alaska, extended periods at around -40 F are common. Although temperatures range as high as 95 F in summer, the ground thaws to a depth of only a few feet. The underlying permanently frozen "permafrost" prevents the water from draining away. The result is the bogs known as muskeg. They not only make ground travel impossible in summer—they also serve as breeding places for the mosquitoes and black flies that torment any humans for miles around.

Despite the marshiness in summer due to lack of drainage, the Alaskan interior is classed as semi-arid. Very little precipitation occurs, and the air is clear and dry throughout the year. However, rain does occasionally fall during spring and fall. And when it does, it is likely to freeze onto everything it strikes, including wings of parked airplanes.

Reason for this is a temperature inversion due to the high rate of ground radiation resulting from

the dry air and the shortness of the sunlit periods and to the absence of strong winds. The average height of the inversion at Fairbanks is 2200 ft. The mean temperature at that level is 31 F higher than on the ground.

Along the Yukon valley ice fog is a severe hazard. Still, moist air becomes supercooled through surface radiation. Then a disturbance such as an airplane take-off or merely a man's breathing is enough to precipitate fog over an entire airfield.

Alaska's Arctic coast offers even more difficult working conditions than the interior. In winter, the air is usually clear but very cold and windy. The wind whips the snow into a blizzard that can penetrate even tightly closed aircraft. In summer, the climate is just about as discouraging. At Point Barrow, for example, summer temperatures are reasonable but mists and persistent fogs make it hard to see from one wing tip to the other, let alone from one end of the runway to the other.

Along Alaska's Bering Sea coast, snowfall is extremely heavy, creating a burden on roofs. And the wind is so strong that it is harder to work out-of-doors there at –20 F than in a calm –50 F.

Much of northern Canada and Greenland is covered by ice caps which are in continual gradual motion toward the sea. Portions slide down drain lines as glaciers. The ice doesn't have the plasticity to flow endlessly unbroken over uneven terrain. Cracks as deep as several thousand feet form, then are bridged and hidden by drifting snow.

The ice caps make good sites for airstrips and bases. But the entrances to them are usually up through the glacial areas. The snow-bridged crevasses are a great danger to any party traveling overland to select a site or to supply a base once it is started.

Where Greenland's glaciers have ended, they have left deposits of rock ranging from great boulders to gravel—all of which can interfere with surface travel.

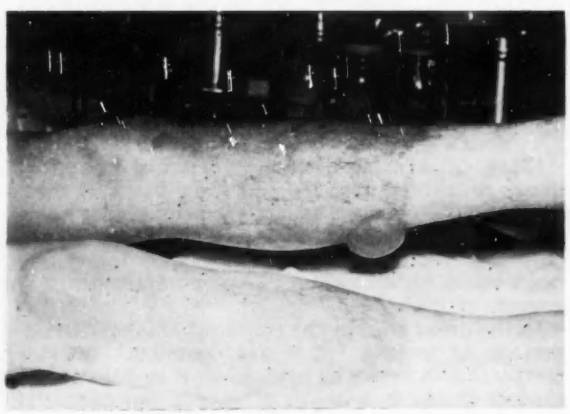
The Arctic Ocean, harsh as it is, conducts heat north from warmer waters and actually softens the climate. In winter its frozen surface is like a huge stove lid through which heat continually escapes. Surrounding land areas have higher temperatures than areas farther south not warmed by ocean heat.

The Arctic basin contains millions of square miles of tumbled ice, churning in the wind and current. Pressure forces one ice block to mount the edge of another, forming new pressure ridges constantly. The ice thickness averages only a few feet, but under ridges it may be scores of feet thick. Between ridges, giant floes of drifting ice, some capable of supporting our largest aircraft, meander lazily over the top of the world.

FLOATING ICE ISLANDS will probably serve as advance bases for our interceptors and attack planes in future wars. Their big advantage is concealment.

The Air Force established a semi-permanent base on Fletcher's Ice Island more than two years ago. Bases such as this would be extremely difficult for an enemy to spot. Almost half the year, from September to March, the Arctic basin is in continual darkness. During the remaining half year, low clouds and fog blanket the surface except for a few weeks in early spring. The jagged pressure ridges defeat the prying eyes of radar.

The pack ice will also protect the atomic submarine from detection and attack. Very small offensive teams built around the all-weather fighter



FROSTBITE results from (left) inadequate footgear or (right) failure to wear long underwear with adequate shoes

and supported by long-range air transport or submarine would possess unparalleled destructive capability. From hide-outs in seas stabilized by pack ice, the submarine could make forays against thousands of miles of strategic coastline. Between strikes, airplanes and submarines would be relatively invulnerable to countermeasures, for such a team could lose itself in the tractless expanse of ice easier than an Arab in the Sahara.

Thermal and weather conditions, although they vary between wide seasonal extremes, are remarkably uniform over vast areas of the Arctic Ocean. Except for a few weeks in summer, surface temperatures stay below freezing. Therefore, snow and ice are building materials. The pump replaces the concrete mixer, and an inexhaustible supply of sea water is never more than a few feet away.

HUGE BASES and scattered supporting outposts have been built, despite the everlasting cold. Military planes now use them every day, and maybe someday commercial planes will, too.

Despite the obstacles, our forces have shipped thousands of tons of building materials into harbors that are ice-free for only one or two months out of the year, lightered them to the shore, and hauled them to construction sites behind special tractors. They have sunk into the frozen earth the foundations for scores of installations ranging from 10-men weather stations to huge bases. They have smoothed permanent runways out of boulder-strewn glacier beds and temporary runways out of compacted snow.

Today it is only routine for military aircraft to take off from these runways on weather missions, supply trips, and instructional flights.

The big bases are a necessity, even though an enemy's single well-placed atomic bomb could reduce a base to a smoking liability. A modern jet plane may consume as much as 20,000 gal of fuel per month. As soon as you set up fuel storage facilities for a few aircraft . . . and the means to defend the facilities . . . and the men to operate and service the equipment . . . and the housing for the men . . . you have a sizeable installation. Success of wartime Arctic operations will depend on having the big bases and keeping them intact.

Someday, commercial planes too may be using the big bases for fast, scheduled service between one part of the northern hemisphere and another. The airlines are already eyeing transpolar routes. Scandinavian Airlines System has made a special flight from Los Angeles to Copenhagen and a charter flight from Copenhagen to Tokyo. The West Coast-Scandinavia flight took only 24 hr and 7 min. Scandinavia to Seattle, SAS estimates, would take only 18 hr via Thule—10 hr less than via New York. On scheduled service from Scandinavia to Tokyo, flying the Northwest Passage would save an estimated 14 hr and 45 min.

SAS encountered no difficulty in navigating, nor have military pilots. The airline relied on Pfund's sky compass, which enables the navigator to take course corrections on the sun, when it is below the horizon, by means of polarized light. Both SAS and the USAF use the Greenwich grid system together with gyro steering, since, of course, magnetic compasses are useless over great areas around the north magnetic pole.

The Air Force finds radar very useful for determining drift, ground speed, and land configuration beneath ice.

FLYING over the Arctic isn't much different from flying over other regions, except perhaps for the view. But the weather complicates every on-the-ground chore.

Much of the territory appears featureless from the air, but pilots say the east coast of Greenland offers some of the most beautiful views in the world.

Visibility is better in winter than in summer, despite the comparative darkness, because the air is clearer. And actually the "darkness" is twilight and may give pilots better visual clues to terrain than sunlight. Throughout the winter-long night snow and ice fields reflect light from the moon, stars, and auroral displays. In the darkest month, December, there is enough light to see open leads in ice and major surface roughness of land. Yet even in October and March the stars stand out bright and sharp enough for navigators to take celestial fixes from 18,000 ft—and airstrip lights show up unmistakably, simplifying landing ap-

Three Developments Facilitate Starting of

Hot Fuel Priming Equipment

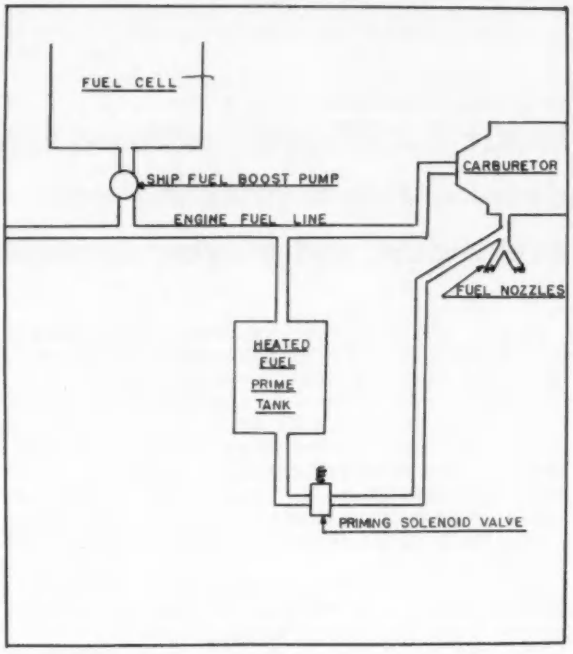
—Everett Rowland, Wright Air Development Center

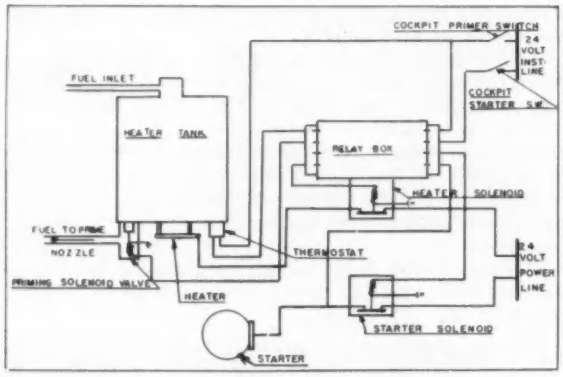
A hot fuel priming system for aircraft reciprocating engines heats standard fuel to the point where vapor pressure is sufficient to start engines soaked at -65 F and even colder.

The system is simple, compact, and light in weight. It consists of a tank enclosing an electrical heater, an electrical control box, and wiring and fuel lines to connect into the priming system. The figures show the system and its relation to the standard fuel system.

To start a cold engine, the pilot engages first the primer switch, then the starter switch. This energizes the heating element, which remains on until turned off by a thermostat in the fuel set for about 220 F. When the heater goes off, cranking and priming begin.

The hot fuel priming system cuts time required to start even a big engine like the R-4360 from several hours of preheating down to less than 3 min.





proaches. Bright summer sunlight on the snow destroys visual contrasts that warn the pilot of obstacles ahead during take-off and landing.

The Arctic is, of course, a most inhospitable area in which to make a forced landing. A knowledge of cold-climate survival techniques is a great help. So is the knowledge that the Air Rescue Service of the Military Air Transport Service has planes and men on the alert to help out all over the world, even in the far north. Nowhere else is speedy rescue so vital.

Eventually ARS hopes to speed up rescue operations through use of the Crash Locator System, which will be a boon to flyers down in the Arctic. The Service hopes to have a crash locator beacon weighing not more than 40 lb installed in the aft section of each large aircraft. On impact the beacon would be ejected manually—or better still, automatically. A parachute carries it to rest if it has been ejected in midair. Gadgetry determines whether the beacon rests on land or water and extends the antenna appropriately. Then the beacon emits its distress message on the international high frequency and the military ultra high emergency

Reciprocating Engines in Cold Weather

Deaerating Cold Weather Oil System

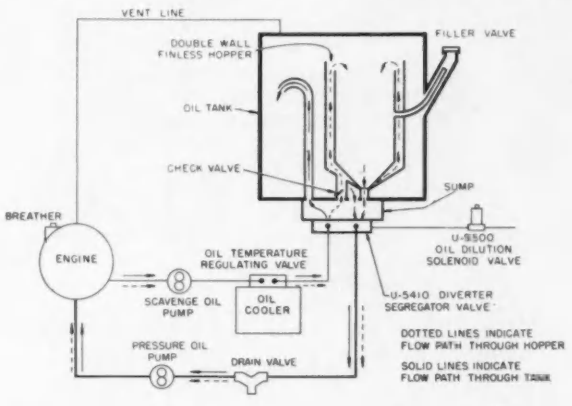
—F. E. Carroll, Jr., United Aircraft Products, Inc.

A system which provides warm, air-free lubricating oil to aircraft reciprocating engines has been developed by United Aircraft Products in cooperation with the Air Force and engine and aircraft manufacturers.

The system is unique in having a mechanically operated diverter-segregator valve and a specially designed high-heat-transfer hopper. The schematic diagram shows their relation to the rest of the system.

Because diluted oil is positively segregated from undiluted tank oil, the diluted oil remains fluid and does not require externally supplied ground oil preheat for extended periods of time. Frozen make-up oil melts fast around the special hopper, eliminating the danger of in-flight engine oil starvation.

The system saves hours of preheating—and is inherently fail-safe in flight.



Low-Temperature Crankcase Oil

—Kenneth Boldt and H. C. Mougey, CRC

Military Specification MIL-0-10295, developed with the help of the Coordinating Research Council, spells out requirements for ground vehicle crankcase oils which have operated satisfactorily in Alaska all winter. The specification was issued May 5, 1950, and at least nine oils have qualified since.

MIL-0-10295 provides that the undiluted oil shall pour at -65 F, have a flash point above 320 F, have a kinematic viscosity of 8500 centistokes maximum at -40 F and 5.75 centistokes minimum at 210 F. Oils must also meet the L-1 480-hour Caterpillar diesel engine test and the L-4 36-hour Chevrolet engine test for MIL-0-2104 oils.

Tests of oils meeting the specification conducted in Army vehicles in Alaska during the winter of 1949-1950 showed that they perform as they are intended to. Experience in both Arctic and temperature climates since then confirms the test results.

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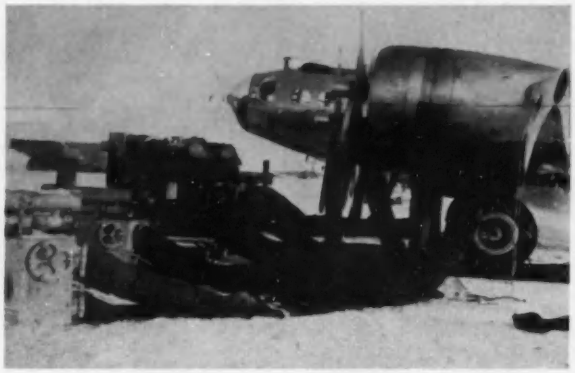
frequency for five min out of each 15 for at least 24 hr. The message reveals the last 4 digits of the aircraft serial number and the time since the crash occurred.

A crash locator triangulation station picks up the message. The station consists of six fully automatic companion direction finders which provide azimuth and other pertinent data for determining the position of a crash. The automatically calculated position appears on a triangulation board for immediate communication to the Rescue Control Center.

The Center dispatches aid to the correct spot at once. The rescue aircraft homes on the crash locator beacon.

This system isn't in operation yet, but there's no technical reason why the equipment can't be built and operated.

Of course, one of the best attacks on emergency landing problems is to take care of the airplanes so that there are no in-flight failures and therefore no emergency landings. The United States Air Force has learned a great deal about maintaining and servicing both airplanes and the ground vehicles that must be on hand to back them up. (Much of



ICE FOG develops from the preheating of the engines of a plane that must take-off after standing days at - 50 F. Under certain temperature-moisture conditions, even a man's breathing can start a chain reaction of precipitation, fogging in a whole air field. Another hazard is blowing snow, which enters parked aircraft through cracks around doors and piles up inside the fuselage. Both these conditions hamper operations in parts of Alaska.

the information has come from tests carried out at Ladd Air Force at Fairbanks, Alaska, and from the Climatic Hangar at Eglin Field, Florida.) The Royal Canadian Air Force also studies and practices Arctic operation. U.S. and Canadian services pool the lessons derived from their experiences and testing.

Ladd Field has determined that aircraft should be kept outdoors as much as possible. Otherwise large changes in ambient temperature bring contractions and expansions that cause leaks in hydraulic, fuel, and oil lines and malfunctioning of instruments. At Ladd, airplanes go into the hangar only for extensive maintenance operations.

The exception to this rule is that when freezing rain is forecast, Ladd puts as many aircraft as possible under cover. When rain falls, it's warm enough outdoors so that the outdoors-indoors temperature differential doesn't cause trouble anyway.

Blowing Snow and Ice Fog

Parked aircraft must be tightly closed and protected with snug engine and wing covers against rain, frost, and snow. Even with engine covers, C-47's at Barter Island on the Arctic Coast have collected full cowls of snow, while high winds drove bushels of snow through cracks around the doors.

Ice fog leaves heavy deposits of frost, if you let it. Some people feel covers are the best way to avoid frost deposits on aerodynamic surfaces. Others favor isopropyl alcohol or ethylene glycol. Ladd uses both covers and isopropyl. Wing and stabilizer covers are left on until shortly before take-off. Then the surfaces are swabbed off to remove any residue and to prevent further deposition during the wait for take-off clearance.

For Arctic service, the Air Force duplicates many instruments and pieces of equipment not duplicated in other aircraft. Vacuum flight instruments, for example, are teamed with electric ones. Radio aids and cabin heaters are doubled too.

Almost all rubber used in USAF Arctic planes is natural rubber. This does mean acceptance of penalties in cases where synthetics are ordinarily preferable. But currently available synthetics just don't retain their elasticity in the cold as the natural product does.

Jet aircraft require relatively less maintenance and servicing effort than do older types. For one thing, there are no propellers to suffer damage from gravel runways. Another advantage is that the only preheating ordinarily required is warming of the cockpit, mainly for crew comfort.

JP-4 Fuel is Satisfactory

Except for an occasional hot start at very low ambient temperature, JP-4 turbine engine fuel is entirely satisfactory at Alaskan bases. Moving a plane from a warm hanger out into the cold will cause ice crystals in the fuel—but the solution is easy: keep the plane outdoors as much as possible.

One trouble with jet aircraft, however, is that accessibility has been sacrificed to aerodynamic cleanliness. Working in heavy clothing accentuates this deficiency. It is hard to do the simplest job wearing three pairs of mittens. And even asking a question takes more time when every face is obscured by a furred hood.

To start an R-1830 engine at -50 F, it may be necessary to preheat it for an hour with an engine-driven gasoline-burning heater. But the heater itself, if kept outdoors as it must be at small bases, will not start without preheating. So the mechanic heats it with a smaller, hand-crank blower-type heater—which he has first warmed with his cigarette lighter.

All in all, aircraft acquit themselves quite well in the Arctic environment. They operate much more dependably than do the heaters, starters, jacks, and other ground equipment. These items tend to start hard, to leak, and to catch fire.

Refuelling trucks, fire trucks, and similar vehicles give little trouble as long as they are kept in first-class condition. It's good practice to overhaul all ground vehicles in the warmer months so that they will be as good as new at the onset of steady below-freezing weather.

In the Arctic cold, metal is more brittle and men are less patient. But air operations can and are being carried out every day of the year.

Human Engineering can reduce accidents,
cut training costs, and eliminate
the need to redesign after manufacture.
So, designers should . . .

Fit The Machine To The Driver

Dr. Ross A. McFarland, Harvard School of Public Health

Based on paper "Human Engineering: A New Approach to Driver Efficiency and Transport Safety" presented at SAE National Transportation Meeting, Chicago, Nov. 2, 1953. (Complete paper will appear in 1954 SAE Transactions.)

MACHINES should be designed from the man outward, with the instruments and controls considered as extensions of his nervous system and body appendages. This implies building the machines and work areas around the operator, rather than placing them in a setting without due regard for their requirements and capacities.

Where human body size and capabilities are ignored, situations may develop in extreme cases such that only 5% of operators can reach and operate the hand brake with comfort. In other cases, only 60% are accommodated for knee height between pedals and steering wheel, while one vehicle accommodates the general body size for only the smallest 40%.

Improvements in ease, efficiency, and operating safety can be had by giving consideration to (1) the application of anthropometric (human body size) data to design, and (2) its use in a dynamic setting. In many instances, an engineer is instructed to design equipment and the operator's area in a manner to "prevent reaching beyond range of vision, avoid off-balance positions, and provide adequate headroom and clearance." He is rarely supplied with quantitative descriptions to meet these requirements. If quantitative measurements are provided, the "average-value" fallacy is often committed.

Such values can be applied to special cases, but arrangements based on averages would be unsuitable for 50% of the operators in a normally distributed group. Provision should be made for 90 or 95%, or any other predetermined percentage, of the potential operators.

Instead of averages, percentile distributions tables should be used which show the measurements for given human dimensions for each 5% of the

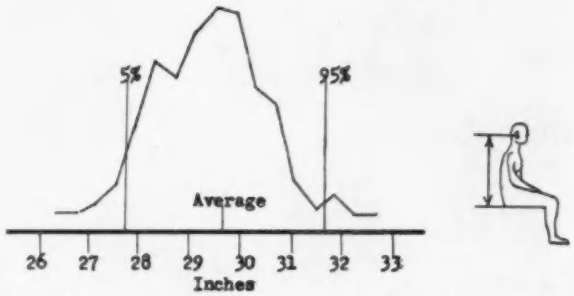


Fig. 1—Since the range in normal sitting eye height is 4 in. (based on percentile distribution tables), this amount of vertical adjustment should be designed into the seat so that at least 90% of drivers can have their eye level at the optimum vertical position for visibility. Use of the average value may leave the seat 2 in. too high for smaller drivers and 2 in. too short for the taller ones

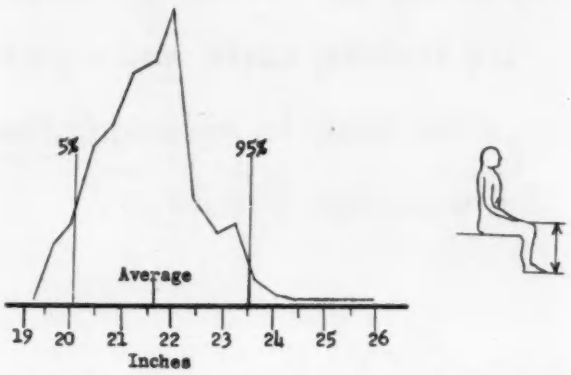


Fig. 2—Since fully 5% of drivers have a knee height of 23½ in., at least 24½ in. (allowing 1 in. for shoe thickness) of clearance must be allowed for the lower leg, that is, between top of the brake pedal and bottom of steering wheel

population, from the smallest, or 5th percentile, to the largest, or 95th percentile. By choosing the 5th percentile as the minimum and the 95th percentile as the maximum, it is possible to design a vehicle to fit fully 90% of the population. To enable such a practice to be followed, the Harvard School of Public Health has taken 31 functional measurements on 360 professional drivers, and the tables are now available.

The problem of integrating anthropometric data with the static dimensions of the cab is one of varying complexity. In some cases integration is relatively simple. For example, it is possible to determine what should be the vertical range of seat adjustment to maintain a uniform optimum eye level for drivers. Here one subtracts the seated eye level of the shortest 5% in the distribution from the tallest 95%. This sets the range of vertical adjustability for this purpose at 4 in. (Fig. 1), and will permit the driver to maintain an adequate eye level position for any given horizontal adjustment. Again, if it is known that the 95th percentile for drivers' knee height is 23½ in. (Fig. 2), there must be at least 24½ in. (23½ plus 1 in. shoe thickness) between the top of the brake pedal and the bottom of the steering wheel to accommodate all but the largest 5% of the drivers.

The problem is more complex when a man is driving a vehicle for then he is in a dynamic situation. Static human dimensions cannot always be applied to the dynamic situation without additional study. However, mock-ups can be built to aid in determining the optimum placement and design of various controls and seats in both static and dynamic situations. We have built such a new test seat.

The physical variables of his environment also influence the efficiency and safety of the operator. These may be broken down into temperature, humidity, and ventilation, noise, and vibration. Fig. 3 shows these in terms of desirable and maximum values for trucks and buses.

As part of our research we tested the noise levels of seven current truck models and found the average to be 69 decibels. The range in one model was 82 to 89 decibels. The tests were made in a closed cab with motor idling. Under highway conditions these readings would tend to be higher.

At the 55 decibel level conversation with normal

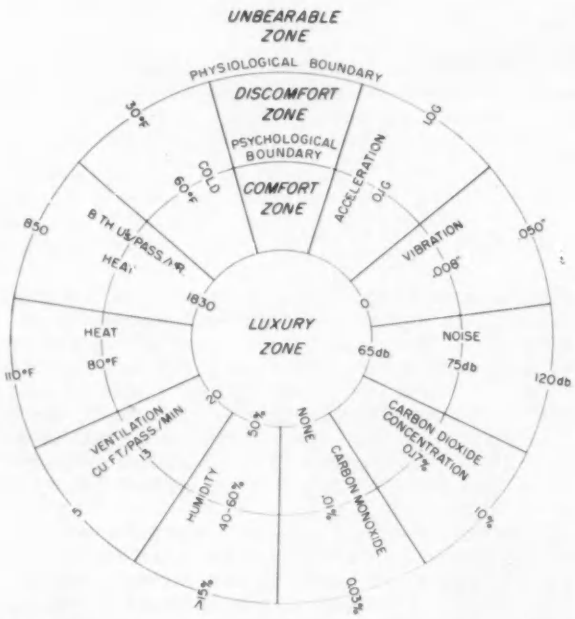


Fig. 3—These limits for physical variables influencing drivers and passenger cars should be considered as approximations since each variable is interdependent on one or more additional factors

voice is intelligible at a distance of several feet. At the 64 decibel level, communication is difficult, while at 75 decibels it is marginal, thus indicating a need for further noise reduction.

Another phase of the investigation was to evaluate 12 trucks and 6 buses to see how well they measured up to drivers' needs. All were 1950 models, representing various types—light and heavy tractors, COE, both gas and diesel, and sleeper cabs. All buses had rear engines, some of which were diesel. From this it became obvious that many features of the working area and instrumentation should be standardized if drivers are to be transferred from one model to another without becoming involved in errors. Brake pedal design and location, for instance, varied greatly between models. It was also found that only three out of the 12 vehicles had any vertical adjustability, while two were lacking in horizontal adjustability.

In general, the findings were borne out by interviews with 250 commercial drivers. Although liking their vehicles and being well adapted to them, they made these important suggestions:

- **Vision:** Defective vision was commented upon three times as frequently by bus drivers as by truck drivers. Bus drivers spoke of blind spots due to large rear-view mirrors, while truck drivers referred to blind spots due to front door posts. Defective windshield cleaning was mentioned, and the value of curved and colored windshields was questioned.
- **Pedals:** Defective in surface characteristics, size, angulation, and pressure requirements.
- **Handbrakes:** Bus drivers prefer pull-back type located at left. Truck drivers prefer pull-up type located at right. Significant comments were made on inadequacy of handbrake design, resulting in low "holding" ability and introducing possibility of error in dual range vehicles.
- **Seats:** 69% of truck drivers desired better adjustment. More angulation was wanted by 27% of the bus drivers. They also desired more shock absorption and better riding qualities in seat, and more adequate curvature in seat back.
- **Steering Wheel:** Comments covered (a) request to incline the wheel to promote efficient arm motion while seated, (b) difficulty in steering at low speeds and during blowout maneuver, (c) poor road shock characteristics and tendency to lose control briefly when vehicle hit potholes or stones on the highway.
- **Instruments:** A few drivers indicated that instruments are illegible, poorly illuminated, improperly located for visibility, and improperly grouped. More adequate devices are needed for warning of system failure. Indicator needles are not uniform in direction of travel, hence errors occur in reading.
- **Switches:** They were felt to be the most dependable mechanical units in vehicle, but location, especially of those needed in motion, needs reconsideration. Location should be standardized and free of obstructions.
- **Brakes:** Brake lag variability prevents drivers from predicting total stopping distance. Both truck and bus drivers would like lag reduced to constant minimum. Brake adjustment on some rear bus wheels not easily adjustable and mechanics at secondary terminals tend to evade adjusting them.
- **Temperature Controls and Ventilation:** Winter temperature controls need improvement. Buses are more adequately heated, although thermostat maintenance is unsatisfactory. Firewall in trucks conducts a great amount of heat during summer, which suggests change in design of forward air vents. Front bus windows develop annoying noise when open at speeds above 43 mph and have to be closed. Some air vents are permanently open and cause discomfort in winter. Air intake in some vehicles permits entry of exhaust from vehicle ahead.
- **Passenger Entry:** Icing of bottom step suggests need for heating. Hand rails poorly designed for passenger use. Outside step too high for elderly or heavy passengers.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion by . . .

Arthur W. Stevens
Automobile Safety Association

Auto makers must recognize that their product is not going to be operated by a driver who is ideal physically and mentally, perfect as to eyesight and reactions, always sound as to judgment. They cannot even rely on the cars being operated by the mythical "average driver." They must plan and design passenger cars for all kinds of drivers, young and old, tall and short, alert and dull, fresh and fatigued.

Questions and Answers

L. C. Kibbee, American Trucking Association, Inc.: Isn't it better to segregate instruments as to their importance, (1) those you have to read while driving, and (2) those that can be read after the truck stops?

McFarland: I agree. I think a study should be made to decide which are the critical instruments as there seems to be a variance of opinion. This has been accomplished finally in flying, but it took 50 years.

Robert Cass, White Motor Co.: Do you feel you have gone far enough with your study on cab design to recommend space in cab, location of steering wheel, location of instruments, and other similar items?

McFarland: There are recommendations in the manual referenced in the paper with variations as a basis for discussion. I feel that these are fairly close. Also, most of the study was made with drivers rather than with designers.

A. K. Simons, Bostrom Mfg. Co.: What effect do you feel the roll of vibration of the cab has on driver fatigue, accidents, and health?

McFarland: This is not reported in the manual, and I am not in a position to relate physical effects.

P&WA Is Shot Peening

PRATT & WHITNEY Aircraft now shot peens over 400 production engine parts and assemblies—the great majority to improve fatigue resistance by bonding together the surface layers where fatigue failures are likely to start.

The list includes gears, rocker arms, crankcases, pistons, tappet rollers, compressor blades, crankshafts, turbine shafts, and many others. The gears are made of carburizing grades of steel. Most of the other parts are AMS 6415 C (a nickel-chromium-molybdenum steel close to SAE 4340) in the hardness range of Rockwell C 35–40.

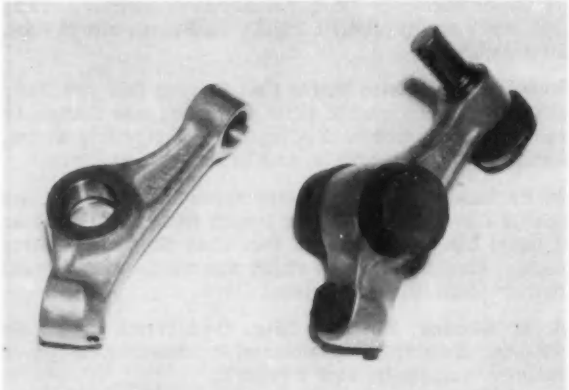


Fig. 1—Rocker arm at left has been nitrided and is ready for masking. Rocker arm at right is masked and ready for peening

To peen the variety of production parts, P&WA has 10 single-nozzle hand cabinets, 10 automatic air blast peening machines, five multi-station wheel peeners, one combination wheel-and-air peener, one endless belt peener, and one rotary track set-up. In general, parts are peened in accordance with AMS 2430 A, the SAE Aeronautical Material Specification on Shot Peening.

We peen steel parts with cast steel shot. It is as effective as cast malleable iron shot, and its longer life makes it more economical despite its higher cost.

Most of our peening operations are quite similar to those of manufacturers in other industries. Probably the biggest difference is that we do more masking. That's because we are usually peening finished, close-tolerance parts complicated by tapped holes and other critical areas that peening would disturb.

Rocker Arms

We peen rocker arms—and most other parts—to pre-stress the surface in compression, thereby lessening the possibility of fatigue failure. Before the peening operation, the rocker arm bore is machined and then nitrided with the rest of the part stopped

Over 400 Parts

H. J. Noble, Pratt & Whitney Aircraft

Based on talk "Shot Peening Applications and Techniques in the Aircraft Industry" presented at Hershey, Pa., Oct. 1, 1954, at a meeting of Division XX—Shot Peening of the SAE Iron and Steel Technical Committee.

off by tin plate. (The nitriding is also to accomplish compressive pre-stressing. The nitrided bore surface oscillating on a silver-plated shaft lasts longer than ball or roller bearings or bronze bushing inserts.) After nitriding, the tin plate is removed, the bore masked, and the rest of the part exposed to peening. Fig. 1 shows a nitrided rocker arm ready for masking and one masked in preparation for peening.

The advantage of peening over all-over nitriding is that peening doesn't require previous surface machining as nitriding does.

With the combined treatments, peening shows up pin points of nitriding that result from faults in the tin plate-to-steel bond. The faults are due to inadequate cleaning or to scale imbedded by blast cleaning at the forging source. But the nitrogen-attacked spots are objectionable only from the appearance standpoint. The residual stress from nitriding and the residual stress from peening are in the same direction and probably of the same order of magnitude.

Aluminum Parts

We peen aluminum crankcases (Fig. 2) and pistons—a fact that surprises many peening experts. They point out that heating to the temperatures at which these parts operate presumably destroys the compressive-stress effect of the peening.

We find that this is at least partly true. Directly after peening, the compressive stress extends 0.030–0.035 in. beneath the surface and at the surface, where it's a maximum, measures about 30,000 psi. Heating to 300 F, the nominal operating temperature, for one or two hours reduces this stress by

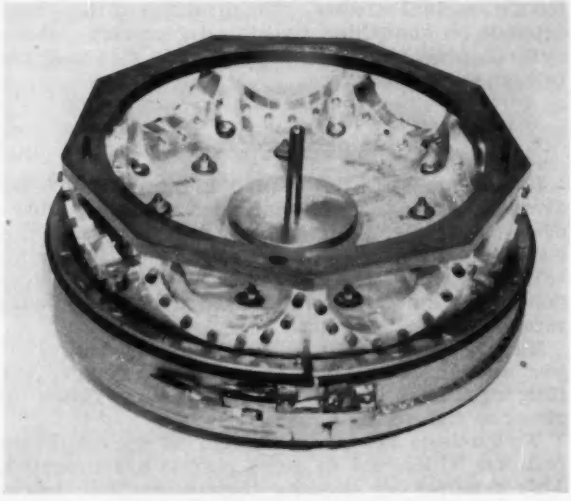


Fig. 2—Crankcase masked for peening

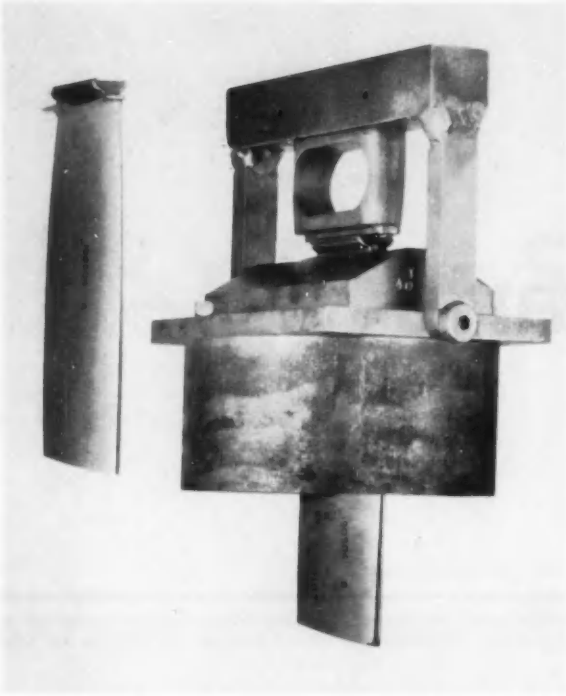


Fig. 3—Fixture for masking compressor blade so that root only will be peened

nearly half. After 6000 hours at 300 F, there is very little stress left.

But the point is that what stress there is, is compressive and therefore favorable.

The advantage of peening is that it puts all surfaces in a uniform compressively stressed condition. Otherwise aluminum alloys in the solution-treated and aged condition may have either compressive or tensile residual stresses. The direction of the stress depends on quenching speed and geometry—which unfortunately cannot be controlled to give uniform results, as peening does.

Machining Corrects Scatter

In fatigue tests, as-peened aluminum surfaces average better than as-machined surfaces. However, the scatter with as-peened surfaces is quite large. If the comparison is based on minimum values instead of average values, as-peened surfaces don't show much advantage over as-machined surfaces.

But the scatter can be reduced. Machining off just enough of the peened surface to remove the roughness is all it takes to bring the low values up closer to the mean.

We machine 0.005 in. maximum off the crankcase pads on which the cylinder barrels are mounted. This removes all peening impressions but leaves the surface compressively stressed. The resultant improved fatigue resistance has ended galling and small fatigue cracks formerly experienced on aluminum crankcases.

Two Unusual Applications

There are two parts we peen for reasons other than compressive prestressing. We peen the bore of an AMS 6440 tappet roller to produce a multidirectional surface finish adequate for holding in place a press-fitted bronze bushing.

We also use peening to inspect the silver-to-steel bond of silver-plated steel parts that can't be inspected by heating. Peening raises blisters where the bond is poor, as heating does. We have worked out charts which show the necessary intensity or arc height for various plate thicknesses. A companion chart shows the amount of silver to be removed for clean-up after peening.

Our laboratories are experimenting with peening titanium. All of our work has shown that peening improves fatigue properties—which is contrary to the results obtained by Herman Hanink of Wright Aeronautical.

On compressor blade root attachments, our tests indicate improvement from 10 to over 40% in endurance limit—the magnitude apparently depending on the means by which the root was generated. Peened blade roots give more consistent, as well as better, results than unpeened blades. (We peen the root only, of course, we do not roughen the airfoil surfaces. Fig. 3 shows the masking.)

Laboratory tests on Westinghouse high temperature fatigue equipment show that at least on one alloy tested, heating does not destroy all the benefit of peening. Where peening showed an improvement of 30% over smooth specimens at room temperature, there was still an improvement of 22% at 400 F and 17% at 600 F.

On the basis of these test results and others, we feel it's logical to assume that shot peening can neutralize the undesirable residual stresses in titanium due to machining or grinding.

We Don't Peen Magnesium

One material we have never peened in production is magnesium. Our laboratory fatigue tests showed that unless the peened surfaces are machined smooth again, peening is almost as likely to do harm as good. Besides, cast iron shot contaminates the surface to the extent that corrosion is a problem. Plastic shot and lead shot, while they don't cause corrosion, don't give enough peening effect to be attractive.

Since we first investigated the peening of magnesium, Dow Chemical Co., a large supplier of magnesium, has made considerable progress in developing magnesium-peening techniques. Very substantial benefits are reported on landing wheels. However, we don't expect to be peening magnesium engine parts that operate at elevated temperatures because it is reported that the effects of peening practically disappear at temperatures as low as 200–250 F.

(Talk on which this article is based appeared in minutes of SAE Division XX's Sept. 31–Oct. 2, 1953 meeting but, unlike papers presented before technical sessions of SAE National and Section meetings, it is *not* available in preprint form.)

Accumulators Can Deliver More Car Hydraulic Assists

George W. Lewis, Electric Auto-Lite Co.

Based on paper "Automotive Electro-Hydraulic Power Systems" presented at SAE Annual Meeting, Detroit, Jan. 13, 1954.

AUXILIARY hydraulic power systems are taking more and more car-operating burdens off motorists. But if this trend is to continue, then the trend toward providing each hydraulic-assist device with its own power source must be halted. What's needed is an auxiliary power hydraulic system that can supply power to a number of independent hydraulic devices. And the closed-center type of system with an accumulator fills the bill. It rates the nod for these five reasons:

1. A number of work cylinders can be operated at the same time without mutual interference.
2. A supply of oil under pressure is available for a certain number of operational cycles even when the car engine is not running.
3. Pump size is usually smaller than that used in the open-center type of system.
4. Momentary available rate of discharge is very high, permitting very fast follow-up in the steering gear, brake servo, and similar units.
5. Lower noise level, since oil flows only when a hydraulic unit is in action.

Put still another way, the closed-center accumulator system closely parallels present electrical systems in power-generating, regulating, power-storing, and load-demand characteristics.

Keeping these facts in mind, let's review the essential differences between open- and closed-center hydraulic power systems. (See Fig. 1.)

Open-Center System

The open-center system has a pump and a pressure relief valve in the pump line. A flow-control valve directs a certain rate of flow to a control valve, the remainder of the pump output being directed into a return line.

When the control valve is in neutral, the fluid circulates through the valve ports with a certain amount of back pressure, then returns to the tank without doing useful work.

When the valve spool is moved, the port area on one side is connected to the pump line, and the port area on the opposite side is connected to the tank. Now, with pump pressure on one side of the piston, and little or no pressure on the other side, the piston moves, performing useful work.

This system does provide good control of the working cylinder. Also, its circuit is relatively simple. But it is not well adapted to the operation of several work cylinders without mutual interference.

Closed-Center System

In the closed-center system, the pump output flow passes through an unloader valve. This valve is a switching device. It directs the fluid to an accumulator until it is filled to a predetermined pressure, then pump flow is directed back to the tank. When the pressure in the accumulator drops to a certain value, the unloading valve again switches the pump flow back to the accumulator.

The control valve in this system is connected to the accumulator line. When the control valve is in neutral, the cylinder ports are blocked off and there is no flow. When the control valve is moved, one port is opened to the accumulator line, and the other opened to the tank line. This moves the piston, thereby performing work.

Several cylinders and control valves may be connected to this system and operated simultaneously without mutual interference.

For this reason, as well as the other reasons mentioned earlier, the author favors using a closed-center accumulator-type hydraulic system in automobiles.

Assuming that such a system is to be used, it might be interesting to consider its major components in more detail.

The accumulator could be a double-shell piston type, preloaded with nitrogen gas. (See Fig. 2.) This type of accumulator can be mounted in any position. What's more, its dimensions can be varied

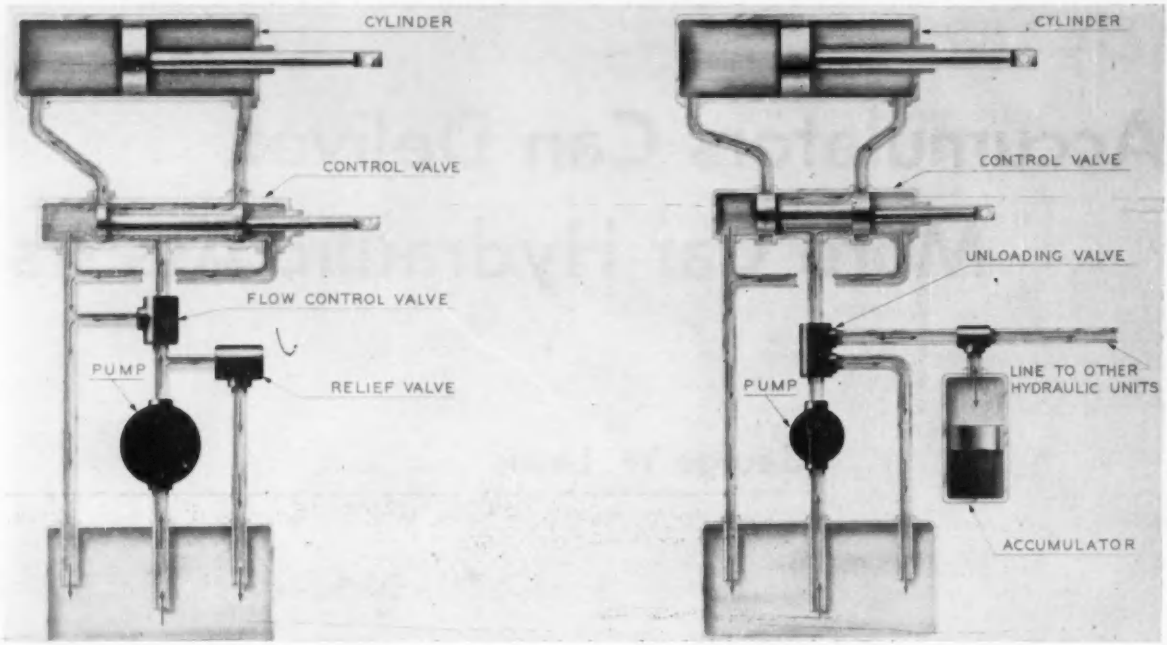


Fig. 1—The open-center hydraulic system (left) is not well adapted to simultaneous operation of several work cylinders without mutual interference. The closed-center accumulator-type system (right) can serve several cylinders simultaneously

to meet the requirements of a particular installation. Such a unit also provides design flexibility in that the pressure per cu in. can be easily varied to suit the needs of the hydraulic system.

In an engine arrangement where a separate drive for the hydraulic pump is not practical, the pump can be combined with the generator. This makes a very compact unit. As shown in Fig. 3, the pump is housed on the end of the generator, together with a reservoir and filter.

Car-Application Considerations

Closed-center accumulator-type hydraulic systems, therefore, seem to have a lot to offer passenger-car designers. But the systems will have to be fitted to automobiles in a practical manner.

Basic hydraulic power lines will have to be designed into the chassis of a vehicle so that any combination of hydraulically actuated units can be installed on the assembly line . . . or after the vehicle leaves the factory. And this must be accomplished without creating an untidy maze of plumbing.

Hydraulic devices should be designed for service and installation as units. No special bleeding or connection techniques should be required. It should be possible for semi-skilled workmen to install them.

The concept of connections and fittings will also have to be looked into. Present threaded and flared connections perform quite well at high pressure only

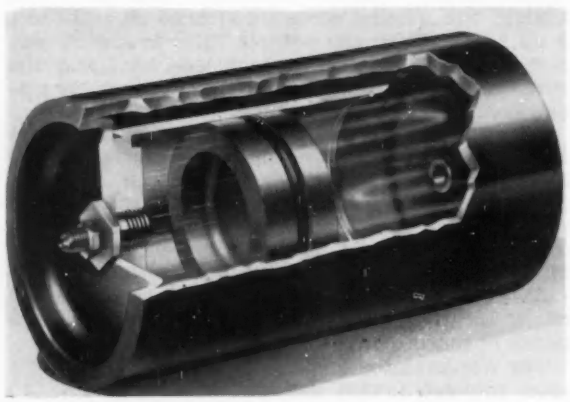


Fig. 2—The accumulator in an automotive closed-center hydraulic system could be a double-shell piston type, preloaded with nitrogen gas

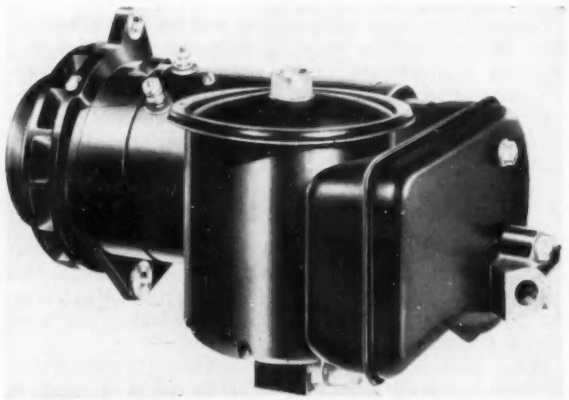


Fig. 3—Where a separate drive for the hydraulic pump is not practical, the pump can be combined with the generator

when assembled by careful and competent craftsmen. And it goes without saying that leakage of hydraulic fluids in the vehicle cannot be tolerated.

In short, the hydraulic system must be entirely reliable, low in cost, and fully satisfy a large and increasingly critical motoring public.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Excerpts from Discussion by . . .

R. H. Fritzges

Hydromotive, Inc.

My experience with a major bus manufacturer in the design and production of over 500 city-type buses with hydraulic controls has strengthened my liking for a central hydraulic power system.

Using a system with 1000 psi operating pressure, we experienced only minor troubles with commercially available flare-type fittings and dryseal pipe threads. A high grade of quality control in the manufacture of the pipe threads was, however, recognized to be quite important.

No special training was required for the workmen who installed the tubes, hoses, and units making up the hydraulic system. Also, very little educational effort was needed for the men who performed the final check and initial run-in.

We had an excellent opportunity to compare open-center and closed-center steering because we provided both on the same size bus. The difference in steering effort was not measurable nor was there any noticeable change in stability, recovery, road feel or response. However, it was necessary to step up the pump speed on the open-center gear model to avoid the possibility of the driver catching up with the power. This increase in pump speed and the resultant higher flow velocities caused high back pressures at top road speed. A suitable compromise was effected by using a flow-control valve set high enough for the necessary steering rate at low speed. This control valve also eliminated unnecessarily high flow rates at high road speeds.

James Robinson

Vickers, Inc.

I agree with the author that an ideal system for hydraulically operating various automobile components would include a central pumping source. I do not think, however, that the system can be even remotely connected with similar types of systems now used in aircraft. The functions are entirely different. What's more, the basic consideration in any accessory used in passenger cars is cost.

The main difficulty in a constant-pressure passenger-car system would, I believe, be in the steering gear. Most present systems use about 0.007 in. movement of a valve to create maximum steering effort. Were a constant-pressure system used, the construction of this valve would be closed-center from the pump to the steering-actuation cylinder, but open-center from the cylinder to the reservoir (to allow self-righting of the wheels after cornering). The oil entrance to the steering-actuation cylinder could not be 0.007 in. wide because the seal at the pressure port or extreme backlash would then be in evidence. Were the pressure seal appreciably less than the necessary opening on the tank side, in any position other than hard over or fast steering, the loss from the accumulator would be much more than the capacity of the steering gear. And if steering or other hydraulic actuation were required with a dead engine, I am afraid that any normal size accumulator would exhaust itself very rapidly.

It is noted from the author's illustrations that all the valve mechanisms are of the spool type. Although these valves may be small and fitted to within possibly 0.0002 in. clearance, the normal leakage rate would probably exhaust the accumulator in a few hours unless it was enormous.

A very rough calculation indicates that five full steering applications would require an accumulator with a storage capacity of 65 cu in. of usable oil. If this cylinder had an internal diameter of 3 in., piston movement would have to be greater than 9 in. This, in turn, would indicate an overall length of about 18 in. (to avoid an excessive differential pressure).

T. H. Thomas

Bendix Products Division, Bendix Aviation Corp.

Our work on trucks, buses, and passenger cars leads us to agree that the open-center system cannot be adapted to multiple actuation on passenger cars without considerable complication and reduced efficiency. (Cost and simplicity have, of course, been the primary reasons for the selection of the open-center system for power steering only on passenger cars.)

We do believe, on the other hand, that the closed-center system for power steering has not any really usable advantages when compared with a correctly engineered open-center system of adequate capacity.

Our conclusion, therefore, is that the open-center system is preferable for a simple power-steering installation because of its lower cost. A closed-center system, we feel, is advantageous for the same reason (plus those mentioned by the author) when a number of devices must be operated from the same power source.

The passenger-car hydraulic control system problem differs from the others we have faced in a way that is most exasperating. It should be a simple matter to scale down and build similar devices for passenger-car use. It is. But the cost does not seem to come down in proportion to the reduction in size. And it looks as though it will have to come down two or three times that much if we really hope to sell the system.

The second part of the problem is almost equally puzzling. Some of the units have to be designed quite differently for mounting in individual car makes and, in some cases, individual car models. Others have to be designed differently for installation in each type of car body. When we consider the number of car makes, models, and bodies, it develops that we consume as much time and labor adapting the devices to the cars as we would if we designed them in the first place.

We believe our remarks can be summarized by saying that a lot has been done, but a lot remains to be done!

Minimizing Cost of Forgings

IT'S total costs, not just cost of the forging operation, that count in producing forged parts.

Sometimes it's more economical to keep the forging operation simple, even if it adds to the machining needed. Sometimes it isn't.

Usually it's cheaper to waste a little stock than to resink dies frequently. But titanium is a different story.

In a few cases, special-purpose forging equipment pays its way. But that's true only when volume is large.

There are so many combinations of men, material, and machines that can be used to produce a particular forging that finding the best combination is no simple proposition. It's a problem for the production man, metallurgist, and designer to work out together.

Men Versus Machines

They know that simplifying or eliminating machining operations generally increases complexity of the forging design, adding such complications as those of holding size to tighter-than-commercial tolerances, reducing or eliminating draft. Holding size to closer tolerances, for example, may seriously reduce die life, adding a cost which must be balanced against savings to be expected in machining. Similarly, reduction or elimination of draft may require added expensive forging operations which cannot be justified in machining savings.

When small quantities are involved, short-run forge fabrication costs, plus amortization of forge tooling expense, must be compared to the savings realizable in reduced hogging of metal in machining operations. In the case of a large aluminum aircraft forging, 20 pieces of a complex forging made in an 18,000-ton hydraulic press proved cheaper than either riveted assemblies or parts machined from bar stock.

Machines Versus Material

Die wear will in time affect machining costs when growth of a forging begins to slow up machining or requires an additional machining operation. Production men must weigh the decreases in die cost per forging with increased die life, versus increases in machining costs due to growth of the forging, to determine forging growth limits and hence die life for lowest overall cost.

When the forge shop is working with such extremely high-cost materials as titanium, the increased cost of the extra material required to take care of forging growth with die wear may dictate resinking the dies long before the growth affects machining costs.

Even for a particular automotive ring gear forging, dies for which are lathe-turned and thus relatively inexpensive, the economic cutoff point of die life was 14,000 pieces, although growth tolerances specified would permit 17,000 forgings from the die.

Machines Versus Machines

Production men are now hotly debating the degree of mechanization best for certain forging operations. New "production centers" make extensive

Other tips these forging experts dispensed included:

DEAFNESS—Test a man's hearing before you hire him, then if he claims deafness later, you'll be able to find out if his hearing really has deteriorated on the job. Encourage your forge shop men to wear ear defenders. Deafness can cost you money because the trend in compensation is toward treating loss of hearing as making the worker socially inadequate, whether or not he loses earning power.

SURFACE FLAWS—Magnetic particle inspection methods can't differentiate between a surface flaw and a more serious defect. So if you're going to use this kind of quality check, you don't want the surface flaws. Some companies go so far as to order rounds centerless ground or rough turned to remove seams and roll marks so that they won't show up later.

HAMMER DAMPERS—The Korfund foundation installed under hammers up to 4000-lb rating has reduced transmitted vibration and cut hammer maintenance in one shop. There was little effect on noise. The springs have not failed in the 1½ years they have been installed. Attempts are being made to use this type of foundation under larger presses supported on pre-stressed concrete bases.

INDUCTION HEATING—This replacement for oil or gas fired furnaces has compensations for its higher cost and reduced flexibility. Induction heating forms little scale, increases die life, and eliminates furnace warm-up time. It also provides more uniform heating and permits localization of heat if desired. It leaves the working area clean and cool, requires less floor space, and reduces maintenance cost.

LUBRICANTS—Glass fiber has been moderately successful as a lubricant for extrusion of steel but not for forging. For aluminum forging, graphite in lead-base oil is still the preferred lubricant.

Requires Right Combination of Men Materials Machines

Holloway Kilborn and R. T. Herdegen, Jr.

Drop Forging Association — Dominion Forge & Stamping Co., Ltd.

Based on secretary's report of Panel on Forgings held as part of the SAE International Production Forum, Toronto, October 29, 1953. Leader was A. W. Hollar, Dominion Forge & Stamping Co., Ltd.

use of conveying and handling apparatus in conjunction with the billet shear, billet heater, forging unit, trim press, and heat-treat furnaces. The main forging unit is a mechanical forging press, preceded by a forging roll or steam hammer for preparation of the blank for the press. Production rates of the order of 150% to 250% of that attained in a conventional steam hammer shop have been achieved, with comparable man power.

Some of the major problems met so far have been in die design to achieve lowest amount of raw material, reduction of downtime due to breakdowns, and handling of forging stock in the furnace when a breakdown occurs.

There's general agreement that the automated line lends itself to high annual volume production of identical or very similar crankshafts, since the considerably higher investment costs can be amortized over the large volume. For lower volume production or where flexibility for a wide variety of parts is required, the conventional steam hammer center appears superior. Unless volume is high enough to justify two automated lines, the danger of having "all the eggs in one basket" cannot be overlooked.

(The report on which this article is based is available in full in multilithographed form together with reports of the seven other panel sessions of the 1953 SAE International Production Forum. This publication, SP-305, is available from the SAE Special Publications Department. Price: $1.50 to members; $3.00 to nonmembers.)

On the panel which developed the information in the accompanying article were:

A. W. Hollar, Panel leader
Dominion Forge & Stamping Co. Ltd.

H. Kilborn, Panel secretary
Drop Forging Association

R. T. Herdegen, Jr., Panel secretary
Dominion Forge & Stamping Co. Ltd.

W. D. Carruthers
Hayes Steel Products Ltd.

H. Crawford
Thompson Products Ltd.

C. F. Hill
Massey-Harris Co. Ltd.

G. W. Motherwell
Wyman-Gordon Co.

M. S. Reed
Erie Foundry Co.

W. D. Snyder
Ajax Manufacturing Co.

E. H. Zuern
General Motors Corp.

Designers Spell Out Ways for

Cooling Innards

Use Fuel as Heat Sink, One Suggests

Doyle C. Wells, Ryan Aeronautical Co.

Based on paper "Cooling Electric Equipment During Supersonic Flight" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1953.

WHEN supersonic speeds and 15-mile altitudes are commonplace, aircraft equipment will have to be cooled by means other than air. It appears that fuel will be the best choice for an integrated aircraft-cooling-system heat sink. Liquid evaporation, however, will find its place for small isolated pieces of equipment.

The situation at Mach one and above can be summed up this way: (1) any air taken from the outside will have to be cooled before it can be used as a cooling medium, and (2) air inside the aircraft will be too hot to use after steady state conditions are reached.

Solution to the problem is a cooling system that is independent of aircraft speed and altitude. This automatically eliminates atmospheric air as the direct heat transfer medium or heat sink.

Therefore, the heat must either be (1) stored in the aircraft for ejection at a later time or (2) ejected from the aircraft in flight.

The first approach can be accomplished by allowing the heat to increase the temperature of a high specific-heat material, then dissipate the heat at lower altitudes and speeds (or on the ground after the flight). This amounts to nothing more than a time lag system and is applicable only to short flights and low power dissipations.

The second approach can be accomplished several ways:

- Aircraft fuel could be used as a coolant before it is burned in the engine.
- A solid could be sublimed in the presence of a liquid coolant.
- A liquid could be made to boil in a heat exchanger or in passages in the equipment, thus absorbing heat.

Fuel cooling has many possibilities. The specific heat of jet fuel is about 0.6 cal per gm and its density about ¾ that of water. The flow rate in a jet engine of 10,000-lb thrust at cruising speed would amount to some 30 gpm. For each degree centigrade rise in fuel temperature, 2.5 kw of energy could be absorbed. Therefore, for a temperature rise of 20 or 30 deg centigrade, 50 or 75 kw of heat could be dissipated. This is more than ample for any electronics combination in aircraft today.

Sublimation of a solid does not offer as much on a weight for weight basis as either of the other two approaches. What's more, solid refrigerants would have to be manufactured near where they were going to be used. Finally, quantities needed would be large and the machinery to produce them bulky and heavy.

Boiling of a liquid has moderate possibilities as

Continued on Page 55

# of Supersonic Jets

Consider Water-Injection, Says Another

George A. Lemke, Consolidated Vultee Aircraft Corp.

Based on paper "Pressurizing and Air Conditioning a Fighter Airplane—Design Problems and Compromises" presented at SAE National Aeronautic Meeting, Los Angeles, Oct. 2, 1953.

THE present method of cooling supersonic fighter aircraft has reached the point of diminishing returns. Using a ram air heat exchanger and a refrigeration (expansion) turbine to cool the cooling medium—engine bleed air—penalizes airplane performance too much. Such a system requires too much bleed air, weighs too much, and causes too much drag (due to the large amount of ram cooling air needed for high heat exchanger effectivity).

It appears that any relief from present cooling requirements must come from the electronics engineer rather than from the mechanical engineer. Here's why: It is very difficult to increase the efficiency of an expansion turbine more than a few percent. But the electrical efficiency of aircraft electronic equipment is so low that an improvement of only a few percent would reduce the cooling requirement to half of what it is now.

While we are waiting for these new developments in electronics that will permit electrons to be energized without getting so hot, these things can be done:

- Cool the electronic equipment with ram air that is cooled below boundary layer temperature by means of water evaporation when its temperature exceeds 100 F. In other words, use water vaporization as the heat sink rather than refrigerated bleed air.
- Eliminate materials that are sensitive to high temperatures. By permitting higher component temperatures with greater temperature rise in the cooling air, cooling airflow could be reduced.
- Make possible more effective heat exchange by using suitable insulation between high heat sources and temperature-sensitive components. Use surface finishes having the proper degree of reflectivity or absorptivity.
- Establish temperature lag of critical components and permit cooling to be reduced during transient conditions of comparatively short time duration.

The above could be accomplished by providing approximately 40 lb per min of ram cooling air to the electronic gear. Then, during high-speed flight, or when ambient temperature is high, water fog could be injected into the inlet duct, reducing the ram cooling air temperature to about 100 F. (See Fig. 1.)

This water-injection system would be needed only for short time periods. Thus, the weight of the water required would be much less than the weight

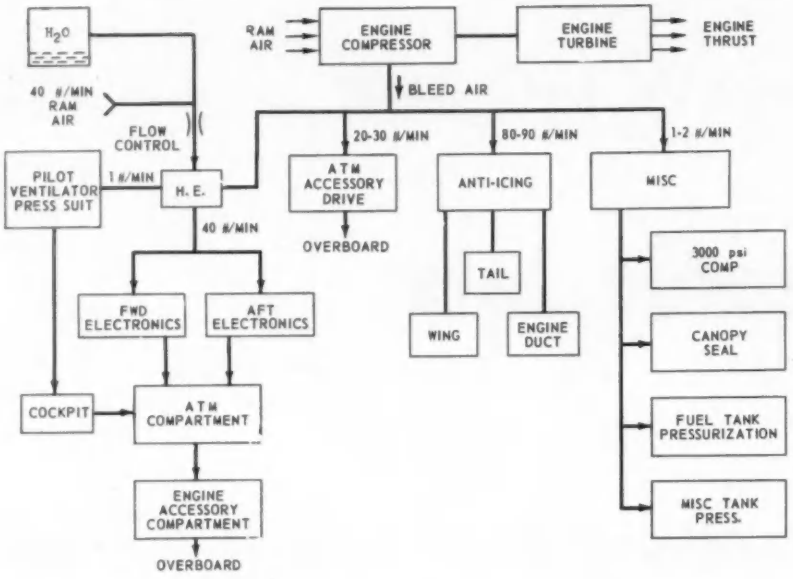


Fig. 1—Schematic of supersonic-jet-fighter cooling system using water vaporization as the heat sink rather than conventional refrigerated engine bleed air

of the heat exchanger and associated ducting in a conventional cooling system.

The amount of water injected into the ram air stream could be modulated automatically by a temperature control system. Ram air cooling weight flow could be varied (by a flow control valve) to provide compatibility between low and high altitude flight.

(The negligible amount of engine bleed air required for the pilot's ventilated pressure suit could be cooled by passing it through a small heat exchanger. This heat exchanger could be located in the cooled ram air duct ahead of the electronic equipment.)

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Excerpts from Discussion by

Paul C. Scofield
AiResearch Mfg. Co.

The author mentioned the possibility of establishing temperature lag of critical components of the electronic equipment so as to conserve air during transient conditions. I believe this should be extended beyond electronic cooling, and considered seriously in connection with cooling of the cockpit itself.

We, as vendors of accessory equipment, have an obligation to inform the air-conditioning engineer in an airframe company of the penalties paid when equipment is designed to meet all transient as well as stable conditions. By the same token, the air-conditioning engineer, should acquaint accessory manufacturers with conditions he considers transient and during which it is not necessary to maintain ideal conditions, especially when such maintenance means weight and space penalties.

To give you an example of the penalties involved, I recall one case in which one of the airplane transient conditions, which had been established as a firm specification requirement, would have dictated a unit 50% larger than otherwise required. The total penalty would have been 50% increase in space, 50% increase in weight, 50 to 75% increase in bleed air flow, and the complexity of additional controls.

I was somewhat surprised that the author did not mention fuel as a possible heat sink for air-conditioning problems. This frequently comes up as a point of discussion, but is seldom used except in the case of oil cooling. It appears, however, that fuel is one of the most likely heat sinks for higher Mach-number aircraft for which ram air is no longer adequate.

W. W. Reaser
Douglas Aircraft Co., Inc.

It is agreed that much can be done by electronic engineers to reduce the heat load of their equipment and to improve the efficiency of cooling. The black box with louvers is a notoriously poor heat exchange device.

The author states that the cooling requirement for electronic gear on supersonic fighter aircraft is approximately four times that of the entire cockpit. This is surprisingly high. Our analysis on similar types of aircraft indicated this load to be only 40 to 50% higher.

Although present electronic equipment is designed for air cooling, it does not follow that air-cycle cooling is essential. Vapor-cycle cooling and evaporative cooling must be considered for each design problem. The weight penalties of these systems may be saved in reduced fuel required for a long range fighter

(because of lower drag of coolant air required in heat exchangers and lower power required in the case of an engine-driven supercharger).

Constant cooling air for constant heat load may not be required. At high altitudes, cooling-air temperature may be well below freezing because of negligible moisture content. Recirculation may be employed to modulate the low temperature. The low temperature can be provided by a bootstrap air-cycle machine which uses its own turbine power effectively independent of ambient air density, provided bleed-air temperatures are not too high. This would greatly aid in the maintenance of constant cooling weight flow.

Injecting water at the discharge of the turbine at sea level to obtain increased cooling does not seem to be a very practical solution. That's because a discharge temperature of 60 F, as mentioned by the author, would already have entrained moisture under normal humidity conditions. It may be possible to spray more water into the air but it would seem undesirable.

W. Merrill

Lockheed Aircraft Corp.

I would recommend that the pilot be given first consideration air-conditioning-wise and cooling of electronic equipment be accomplished by other methods, such as evaporative cooling, bleed-air refrigeration, or even turbine-expanded ram air.

There are some new developments in electronic equipment which will cut down the amount of heat dissipated. Replacement of the hot electron tubes with transistors in many applications is one of them. This change in electronic configuration will greatly increase the thermal efficiency of the equipment and reduce the weight and bulk of the cooling equipment and power drag penalties.

W. C. Shaw

Hamilton Standard Division, United Aircraft Corp.

The author points out that major gains can be made in the design of electronic equipment. I think that point is a good one. It is apparent that the cooling of electronic equipment is a major portion of the job assigned to the air-conditioning equipment. There has been some debate on what percent that is, but it is still a big portion of the total.

As an example of what can be done by an electronic equipment designer, a large amount of attention was given to minimizing power consumption in the design of an electronic fuel control. The result was that this computing device, which has complete control of the jet-engine performance, now uses less than 15 w of power. This compares with the 11 w consumed by the great heaters alone in a pair of 6L6 tubes. Certainly the same principle could be applied with much advantage to other servo-mechanical computing equipment.

Excerpts from Author's Closure

Mr. Scofield expressed surprise that fuel heat exchangers were not considered as a heat sink. This subject is of great concern to those men responsible for fuel system design. At the present time the rise in fuel temperature during high-speed flight is fast reaching a critical limit where the ratio of vapor to fuel is too high for satisfactory fuel pumping at the engine.

Mr. Reaser suggests vapor-cycle cooling, bootstrap cooling, and a separate turbine as methods of obtaining the necessary cooling. Certainly all of these methods should be investigated before deciding which method is best for a given airplane configuration.

I am well aware that no two airplanes necessarily have the same optimum solution to the problem of pressurizing and cooling the cockpit and equipment. However, the penalties involved are in direct proportion to the amount of cooling necessary, as well as the method of cooling.

The main purpose of my paper was to point out that changes in electrical overload requirements, reduced heat loads, use of ventilated suits, reduced pressure drop through electronic equipment, and so forth are necessary to reduce the penalty to airplane performance.

Mr. Merrill, as well as Mr. Reaser, questioned the arithmetic on the magnitude of the electronic cooling loads. This item is rather important inasmuch as the degree of compromise necessary is associated with the relation between electronic cooling and cockpit cooling. The principal purpose of writing this paper was to evaluate the effect of the large increase in the electronic heat load of supersonic aircraft compared to conventional airplanes. Therefore, if the problem did not exist, the compromises would not be necessary.

Use Fuel as Heat Sink . . . continued from page 52

a heat sink. There are many liquids that could be used. None, however, compares to water for latent heat, density, and availability.

Let's suppose a radar system of 1 kw dissipation is to be cooled. Water with a suitable antifreeze could be stored in a tank near the equipment to be cooled. A small centrifugal pump could be used to force the water through thin-wall tubing brazed to the chassis of conduction-cooled equipment or through heat exchangers in pressurized equipment. The water and steam mixture would then be returned to the storage tank.

Water evaporated would amount to 3 or 4 lb per hr (less than 2 qt). Now, flight time of a fighter capable of traveling at supersonic speed would be little more than one hour. Thus, a cooling system with a moderate heat load using a water-antifreeze solution as its heat sink would be light, compact, simple, and would require little power.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Three Steps for Controlling

It takes three operations to control the cost of a manufacturing program, or any of its parts. They are:

1. Setting the target. Boiled down to its barest elements, this involves deciding how many units you'll produce, when, and how much they will cost.

2. Measuring performance. As the program develops, you have to measure performance to see whether you will meet the planned goal. For this you need proper yardsticks.

3. Correcting deviations. If check shows a manufacturing phase falling short of the target, remedial steps have to be taken to bring it into control. Sometimes the target itself needs resetting.

1. Setting the Target . . . company record a key

It's pretty obvious that "having the right thing at the right place at the right time" will yield the least costly manufacturing program. That means setting required activities in relevant sequence, scheduled with proper allowance for time and labor needs, determined from the plant's past performance.

The events in a typical sequence for aircraft manufacture are: (a) contract go-ahead, (b) start of engineering, (c) material procurement, (d) tooling design and production, and (e) fabrication and assembly operations.

Preliminary schedule planning should anticipate effect of changes stemming from errors, test-proving operations, or customer request. Influence of such items which can cause a plan to "fall out of bed" can be gleaned from the plant's past history. Major changes will force a complete reappraisal of the plan.

Engineering is the first "event" scheduled. It starts with an agreement on an elapsed time span, usually predicated on past experience with a similar model. After mockup work, detail schedules for segments of the airplane are set. Engineering, Manufacturing, Tooling, and Planning participate in this schedule development.

The schedule sets the release of engineering drawings in order of manufacturing needs.

Once the engineering schedule is layed out, the manufacturing plan can be developed. Company policies and contract negotiations lay down five basic premises around which the manufacturing plan is designed:

1. Start of planning and manufacturing operation . . . the schedule of engineering release dates.
2. Flight date for first airplane and subsequent delivery schedule.

Manufacturing Costs

1. Set Target

2. Measure Performance

3. Correct Deviations

N. B. Davis, Jr.
Supervisor, Manufacturing Statistics, Lockheed Aircraft Corp., Calif. Division

Based on secretary's report of Control of Manufacturing Costs Panel held as part of the SAE Aircraft Production Forum, Los Angeles, Sept. 30, 1953.

3. Amount of total direct labor loads.
4. Statement of tooling policy with degree of production breakdown.
5. An allocation for an appropriate amount of equipment, material, tools, and overhead services.

Detail schedules are set starting from engineering release date schedules right through to delivery schedules. Correlated with the detail schedules is a forecast by the week of the direct labor load. Area requirements are figured from the labor loads. Anything that the labor hours and peak-rate area requirements can't handle has to be placed with subcontractors. Equipment is determined as part of the plant layout to satisfy work and labor needs. Material also is ordered to meet schedules.

2. Measuring Performance . . . time, product units important

It's important to measure physical output along with labor hour expenditures in controlling a production program. For example, in producing an airplane wing, you might plot the cumulative design manhours as well as the number of drawings to be produced. Then actual figures are plotted against the estimates. If either actual line falls below the target, investigate immediately.

Perhaps manhours expended are less than estimated, but number of drawings remain on schedule. Then the costs may have been overestimated, but the project is in good shape.

Such week-by-week watching of costs and physical product output also can be applied to all phases of the production program.

For example, direct labor costs in detail and assembly operations are a case in point. The basis for measuring sticks of direct labor is a learning curve. These curves can be set up for each department, section of the airplane, or total airplane.

Declining slope of the unit cost should be a reasonable objective. A decrease should be projected so that sufficient pressure is maintained in each budget control group to assure full use of manhours.

Hours control reports and performance graphs usually are published for each fabrication department. A typical "hours performance graph" indicates a slowly declining budget line and a closely

following actual hours line. More details can be watched if warranted and supplementary reports issued showing such things as:

a. Cumulative hours spent on a project in a certain department.
b. Hours per piece per operation.
c. Total cost per shop order.

In assembly departments, an "hours performance report" is issued each week. This shows for that department the assembly job number covered, the job name, the required unit cost at a certain terminal unit, weekly units completed, and the hours per unit.

Tracking the hours per unit as related to the quantity of the week's production is the key control. This information sometimes is grouped by supervisory responsibility or a comparative study of jobs.

Control charts also are set up to measure rate of materials acquisition as compared with the target. One such chart shows a cumulative actual line compared to a schedule for these items:

a. Amount of purchase order commitments,
b. Purchase order receipts, and
c. Inventory usage . . . disbursal to requisition.

Comparison of the actual versus the budget line indicates the time lag on the horizontal distance, and the percentage the item is ahead or behind schedule on a vertical.

3. Correcting Deviations . . . reset target, if need be

When actual performance doesn't jibe with the schedule, one of two things can be done: (1) find the cause for slowdown (if performance is behind) and remedy it, or (2) readjust the initial target if it proves to be unrealistic. Each particular case must be studied for the facts peculiar unto it.

As a matter of fact, production management tries to set goals that are better and better. If detail examination shows that targets or forecasts are too strenuous or in error in concept, targets are reset to reflect the actualities.

Material residue—both generated scrap and surplus inventory—reveal that things are amiss if they go out of line. They reflect on product quality. Costs are kept low within the company by avoiding rework hours.

Rework and scrap hours are reported for the rejected components and materials processed to that stage. Material can be conserved through continued surveillance of surplus, dormant, and scrap material, tools, or equipment. An examination will determine whether the material can be reclaimed and put back into use. Or perhaps it can be made into spares or smaller detail parts, or profitably disposed of in some other way.

The answer to target "misses" is to prevent them before they ever happen. And that means a thorough program of pre-production activities. Without it, the best cost control system won't prevent schedule failures and excessive costs.

(The report on which this article is based is available in full in multilithographed form together with reports of nine other panel sessions of the 1953 SAE Aeronautic Production Forum, Los Angeles, Sept. 30, 1953. This publication, SP-304, is available from the SAE Special Publications Department. Price: $2.00 to members, $4.00 to nonmembers.)

. . . And on the Panel

which led the discussion highlighted in this article were:

• **Panel Leader**

J. T. Gray,
assistant to the manufacturing manager,
Lockheed Aircraft Corp., Calif. Division

• **Panel Co-Leader**

K. P. Bowen,
vice-president—manufacturing,
Northrup Aircraft, Inc.

• **Panel Secretary**

N. B. Davis, Jr.,
supervisor, manufacturing statistics,
Lockheed Aircraft Corp., Calif. Division

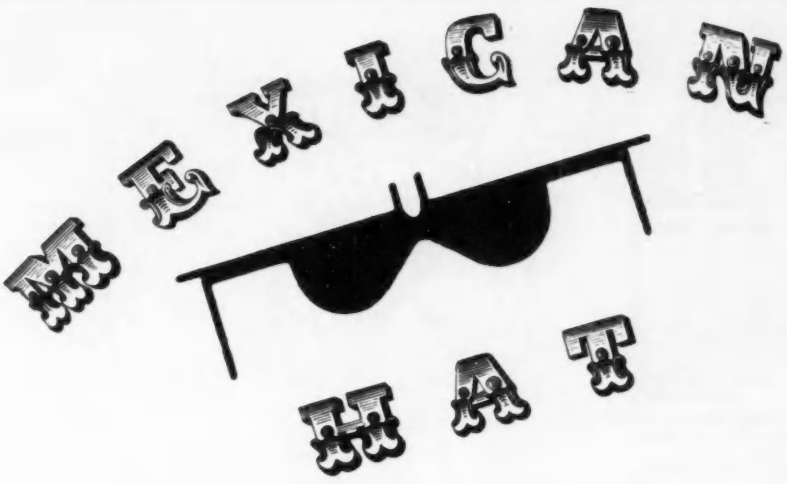
• **Panel Members**

H. J. Brown,
chief accountant,
Lockheed Aircraft Corp., Calif. Division

Morrie Harper,
supervisor, cost analysis & standards,
Douglas Aircraft Co., Inc., El Segundo Division

Kermit Stegen,
supervisor, production analysis,
scheduling department
North American Aviation, Inc.

Elwood Buffa,
School of Business Administration,
University of California at Los Angeles



Combustion Chamber Used in New Mack Diesel

Bruno Loeffler, Executive Engineer, Engine Division, Mack Motor Truck Corp.

Excerpts from paper, "Development of Improved Automotive Diesel Combustion System," presented at the SAE Diesel-Engine Meeting, Chicago, Nov. 4, 1953. This paper will be published in full in 1954 SAE Transactions.

BASIS of the combustion chamber being used on the new Mack diesel engine is the so-called "Mexican hat" shaped cavity in the piston head.

The center section, just below the nozzle, is formed as a raised cone. This places maximum air in the periphery, where the fuel sprays can reach it.

This and other details of the combustion chamber were determined after comprehensive study and testing. Several phases of this development work are presented below.

Induced Swirl and Squish

When high output at high speeds is required, air movement is essential. This air movement must be of an orderly nature and of a velocity that assists the injected fuel to be burned completely.

This air movement, or swirl, can be induced by a masked inlet valve or by an inlet passage so disposed that it imparts direction of airflow tangential to the cylinder and slightly downward, together with locally restricted port opening clearance. (See Fig. 1.) Both arrangements are used with success.

We have tried both types and like the venturi port better. It allows the inlet valve to turn by means of a postive-type rotator, which will keep the valve seat clean and reduces valve-stem scuff. This cannot be accomplished with a positioned inlet valve. There is very little argument as to which gives the higher volumetric efficiency. Both types will give a slight drop in air delivery.

Squish is an air movement that takes place within the combustion chamber just after the fuel is in-

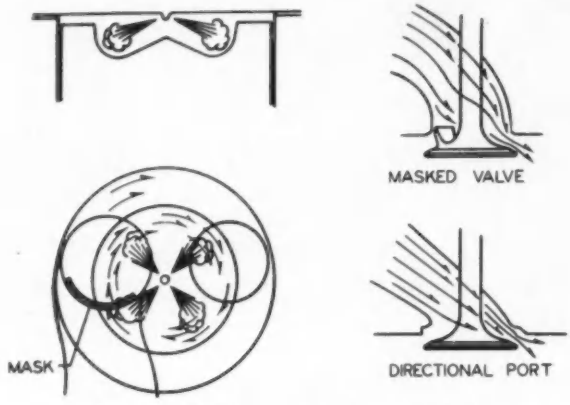


Fig. 1—Intake induced air swirl and how it is produced

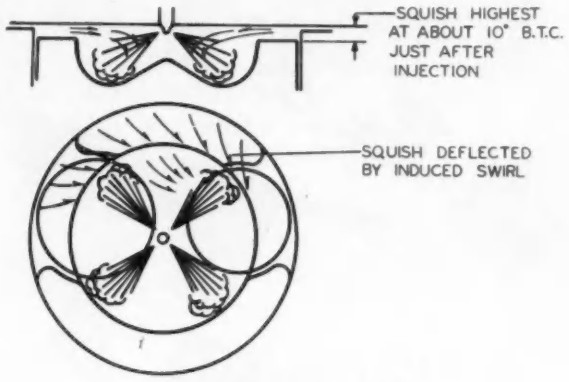


Fig. 2—Piston induced squish

jected. (See Fig. 2.) The air trapped in the quench area is squeezed out of its space at an accelerating rate and enters into the combustion chamber. The body of air, being thus displaced into the chamber and into the already swirling air, increases the air velocity. This assists the swirl to devour the fuel droplets that have been injected into this vortex of hot air.

The ratio of chamber diameter to piston diameter determines the squish velocity. Also affecting this velocity is the distance remaining between head deck and piston when the latter is in its uppermost position.

We have developed a simple formula to arrive at these velocities. It assumes, for convenience, that the air is incompressible. Of course, it is not. For our comparison, it was sufficient to show certain effects by changes in the chamber proportions. Another item affects squish velocity as well. It is the relation of stroke to connecting-rod length.

This factor exerts such a small influence that it can safely be ignored. However, the height of the quench space has a very important effect upon squish velocity. Obviously, the closer the piston rim approaches the cylinder-head deck the greater the squish velocity. Naturally there were mechanical limitations, such as head gasket thickness, piston expansion and rocking, connecting-rod and main-bearing clearance, expansion differential be-

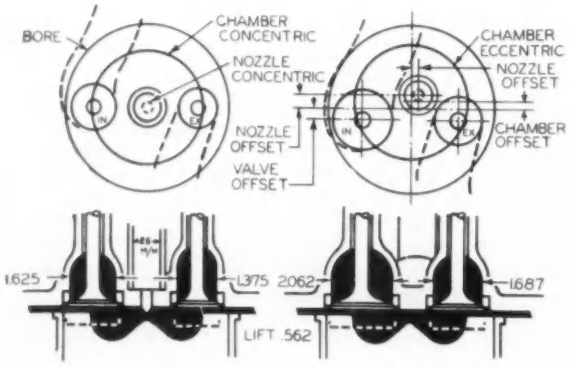


Fig. 3—Ideal (left) and practical (right) valve and nozzle arrangements, with their effect upon valve size

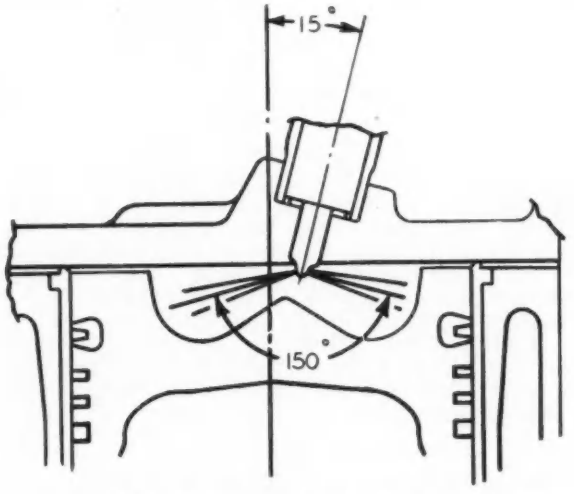


Fig. 4—Nozzle and combustion-chamber relationship

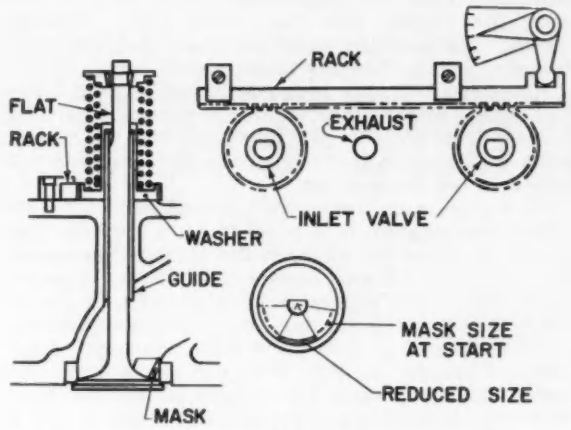


Fig. 5—Schematic arrangement for mask positioning on inlet valve

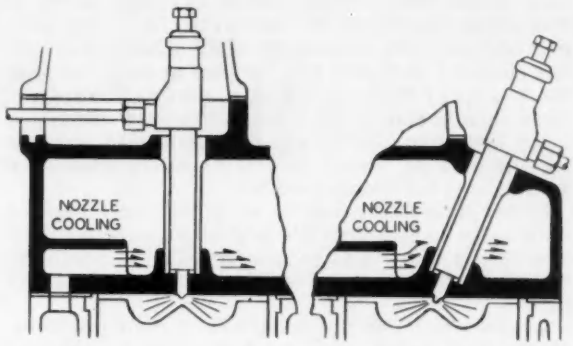


Fig. 6—Nozzle arrangement and method of cooling—left: vertical, inside of valve cover; right: inclined, outside of valve cover

tween the block and the piston and connecting rod, and connecting-rod stretching at overspeed.

Designing the Head and Chamber

The ideal head carries the nozzle in the middle and has the valves arranged as shown in the left view of Fig. 3. This looks good until one tries to draw in the valves and inserts.

As can be noted, the inlet passage had a diameter of only 1.625 in. We needed at least 2 in. to have airflow equal to that with the energy-cell type.

With proper valve sizes, it was not practical to have the valves in line with the nozzle and on the engine centerline and still have the valves opening directly into the bore and of sufficient size. Fig. 3 shows the crowded condition in the design at the left, resulting in the restricted size of the intake port.

We did not want recesses in the cylinder liner. In fact, we could not because of the dry-liner design in this engine. From the experience we have gained in our experimentation, it would have been a mistake. It would have affected our fuel economy adversely.

To overcome this, the valves were moved to one side from the longitudinal centerline and the nozzle to the opposite side. To obtain good nozzle cooling, the nozzle was inclined to the maximum practicable.

Naturally, with the nozzle tip so far off the center

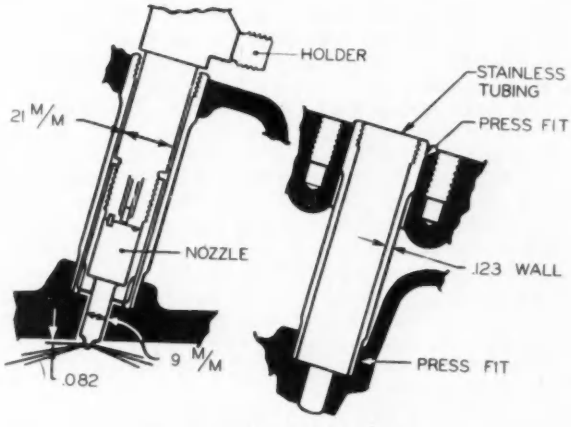


Fig. 7—Nozzle holder tube

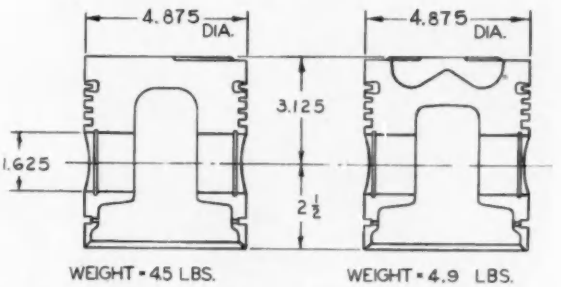


Fig. 8—Piston design for energy-cell (left) and open-chamber (right) type of engines

of the engine, we could not leave the combustion chamber in the center of the bore. We moved it close to the center of the nozzle, as shown in Fig. 4. This offset the piston in relation to the nozzle location and resulted in more air being available on the left side of the nozzle tip. It just so happens that the two spray holes on the side pointing toward the more remote side of the chamber deliver about 2% more fuel than the other two. This may account for the lack of smoke that is normally associated with off-center nozzle position.

In our early experimental work, we used a masked inlet valve to establish the best swirl velocity. The size of the mask was purposely selected too large and was gradually cut down to a trifle, as shown in Fig. 5.

In order to move the mask into various positions, all six inlet valves were hooked up by a rack and pinion. This helped to reduce the down time for the various positions.

When we modified the port, we removed the mask from the valve and incorporated a local restriction into the valve port. The insert is recessed into the head deck. The resulting recess is cut away in the direction of the entering air. The opposite half of the recess is used to deflect the air. This gave us another advantage. It made the valve heads flush with the deck. The advantage is that the piston recesses disappear or become very small. Since the port entrance is flatter, it was later found necessary to increase valve lift to 9/16 in. It was previously ½ in.

Nozzle Installation

We decided to have the nozzle inclined. There are arguments for and against it. Fig. 6 shows a comparison of the two arrangements.

In favor of the inclined nozzle is the fact that nozzles can be removed for cleaning without disturbing the cylinder-head covers. This is not only a convenience on engines arranged vertically, but it also improves conditions on engines laid horizontally. Removing the head covers lets oil run over the engine, and the whole thing becomes messy. The least the head covers are disturbed, the less dirt enters into the head mechanism.

Another advantage is the detection of joint leakage, which might occur. There is no nasty packing for the fuel line to pass through the head wall. Leak-off lines are easily accessible and can be properly checked for leakage.

Of course, with the nozzle inserted from the outside of the engine, it is possible for a careless mechanic to allow dirt to enter the combustion chamber upon removal and replacement. This, however, is as true of the energy-cell type, which, in the 15 years that we built this engine, never proved serious.

What seemed at first to be a disadvantage of the inclined nozzle, namely, that the spray from the lower holes was some 2% greater in volume than from the upper ones, actually turned out to be an advantage in connection with the offsetting of the combustion chamber. The only penalty was the necessity for doweling the nozzle holder to assure correct positioning of the spray holes.

This was a small price to pay for escape from the many drawbacks of the vertical nozzle. One of these is that, with the nozzle under cover, possible joint leakage cannot readily be detected. The packing between the tube and head, mostly accomplished by neoprene blocks, is not durable.

Leak-off connections must also pass through the head, again through the packing. When fuel packing leakage occurs under the head cover, it cannot easily be detected.

Cooling of the nozzle tip is important. A copious flow of water directed against the tube is necessary.

For the nozzle boss or tube, various designs were studied. Finally, we decided on the design shown in Fig. 7. Here, a stainless-steel tube is pressed into a recess in the top and bottom decks. Cooling is good. It offers solid metal for the gasket to rest on and, because of the tube material used, does not corrode or expand excessively. A thread is added to the top for removal with a puller.

Piston

Fig. 8 shows the comparison between the "Mexican hat" open-chamber and the flat energy-cell type of piston. Both have the cast-in Ni-resist insert and a keystone top ring. All remaining rings are identical. Both pistons are of pretty rugged design to resist deflection.

We have found that ring sticking is greatly reduced by the keystone ring design. One would think that, because of the lowered ring-belt temperature, ring sticking would not occur. We have tried straight rings and found the keystone rings a great improvement. Add to this the cast-in insert, which resists ring-groove pounding, the setup is quite good and resulted in longer ring life and improved oil consumption. In fact, after 140,000 miles of grueling tractor operation, we still get 300 mpq and the top bore wear was just over 0.003 in.

Fig. 9 shows a photograph of one of the pistons from this engine.

(Complete paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ a copy to members; 60¢ a copy to nonmembers.)

Fig. 9—Typical piston condition after 140,000 miles of tractor operation

It's Still 12 Volts!

H. L. Hartzell, Delco-Remy Division, GMC

Based on paper "It's Still 12 Volts" presented at SAE St. Louis Section Meeting, Oct. 13, 1953.

A YEAR ago we said a 12-v electrical system could meet the growing needs of passenger cars. Today, we have facts to prove it.

Behind us we have a year's experience with large-volume production and operation of 12-v passenger-car equipment. And this experience has served to strengthen our earlier position—that a 12-v system is the most practical and cheapest way to meet the mounting electrical needs of today's cars.

Why 12 Volts

Such a system, it has been found, offers these advantages:

- Better ignition performance, with a simple, single-coil, single-breaker combination.
- Higher output and better low-speed performance of the generator.
- Higher-speed, lighter-weight cranking motor.
- Improved electrical distribution system.
- Better performing auxiliary motors.
- Extended regulator contact life.
- Longer radio-vibrator life.

Here, in summary form, is a report of our experiences with the 12-v system in 1953.

Ignition Complaints Plunge

We have had exceptionally few ignition complaints as compared with previous years. The greater ignition reserve of the 12-v system has eliminated the need for most early contact changing, plug servicing, and general tinkering; work necessitated in the past by complaints of missing during acceleration or missing at high speed.

Few Run-Down Batteries

Complaints of run-down batteries have been few and far between. This can be traced to adequate generator output and freedom from oxidized regular contacts.

One important feature of the 12-v generator is that its higher voltage permits more turns of smaller wire to be used in the fields; so many more turns that it is possible to get much stronger fields with only 80% the field current of a 6-v generator.

The improved regulator contact performance obtained can be attributed to the lower field currents of the 12-v generators.

Owners Like Faster Starts

Higher cranking speeds and faster starts brought forth many favorable comments from owners of cars equipped with 12-v systems.

Favorable Reports on Lamp Life

Lamp life in the larger sizes has been found to be comparable to that of similar 6-v lamps. (And we are learning how to improve the life of smaller 12-v lamps.)

Radio power-supply vibrators have been giving better life. (This is because they carry only about half the current of 6-v units.)

What's more, improvements in manufacture are bringing the life of 12-v radio tubes in line with that of 6-v ones.

When it comes right down to it, the manufacturing and servicing problems encountered have proved to be rather minor, considering the magnitude of the change to 12-v. Truth of the matter is that these problems have been fewer and easier to solve than we anticipated.

Yes, with 1953 models behind us, we say, "It's stili 12 volts."

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

AERO Production Men

ECONOMY was the password at the SAE Aeronautic Production Forum on April 12, at the Hotel Statler, New York. More than 700 manufacturing men sharpened their pencils together in working out ways of trimming dollars from production costs of aircraft, engines, and accessories.

Luncheon Speaker Roger Lewis, Assistant Secretary of the Air Force (Materiel), added even greater urgency to the dollar-saving discussions. Said Lewis: "Probably taken on the whole, our equipment is the best in the world. However, it is neither as good as we can make it, nor is it as good as it must be. We still do not get it soon enough and we still pay too much for it."

He implied that engineers and manufacturing men face an even tougher cost-cutting job than ever before. That's because the military are accenting research and development (aiming for improved performance and quality) and are tapering off on production.

He left his audience of nearly 500 with this challenge: "The problem of shifting from the high rates of production, and emphasis on quantity necessary to equip the Air Force, to lower rates emphasizing quality necessary to maintain it and keep it modern, is not to be under-estimated; but we have, for the first time, a program and the time for accomplishing it. You have met the other great challenges which have been thrust upon you, and there is no doubt that you will meet this."

Meeting the Challenge

As if in direct reply to Secretary Lewis, discussions all day at the seven Production Forum panels yielded participants rich take-home pay in cost-saving ideas. Manufacturing men touched many bases in their cost crusade. Close cost control attuned to the plant's individual needs was urged in most areas . . . whether it's manpower, machines and methods, or materials.

Labor costs, directly or tangentially, crept into most panels discussions. In the Factory Cost Control panel, methods of collecting direct labor time received an airing. One company said it has one timekeeper to each 70 direct labor people. It uses a routing sheet to follow a piece through each operation. Another plant held out strongly for its job card system.

Some shop men felt sizable savings were possible by better control of overtime. They advised that you can't just decide off-the-cuff whether night operations, six-day week, or holiday work is the cheapest. Each company has to weigh the pertinent elements in its own case. For example, perhaps the use of additional machinery might cost less than overtime work.

Men at the Factory Personnel Relations panel looked ahead several years and found that the "age of automation" might subordinate the machine operator to a new type skill . . . the electro-hydraulic maintenance man. Such a man, with a combination of electronics and hydraulic knowledge, will be the key to successful operation of automation machinery.

But even with automation, an executive warned, management will have to deal with people. It may be even more important in the future. He alerted management to action right now, particularly in selection. The average employee at age 20 represents a $200,000 investment to industry.

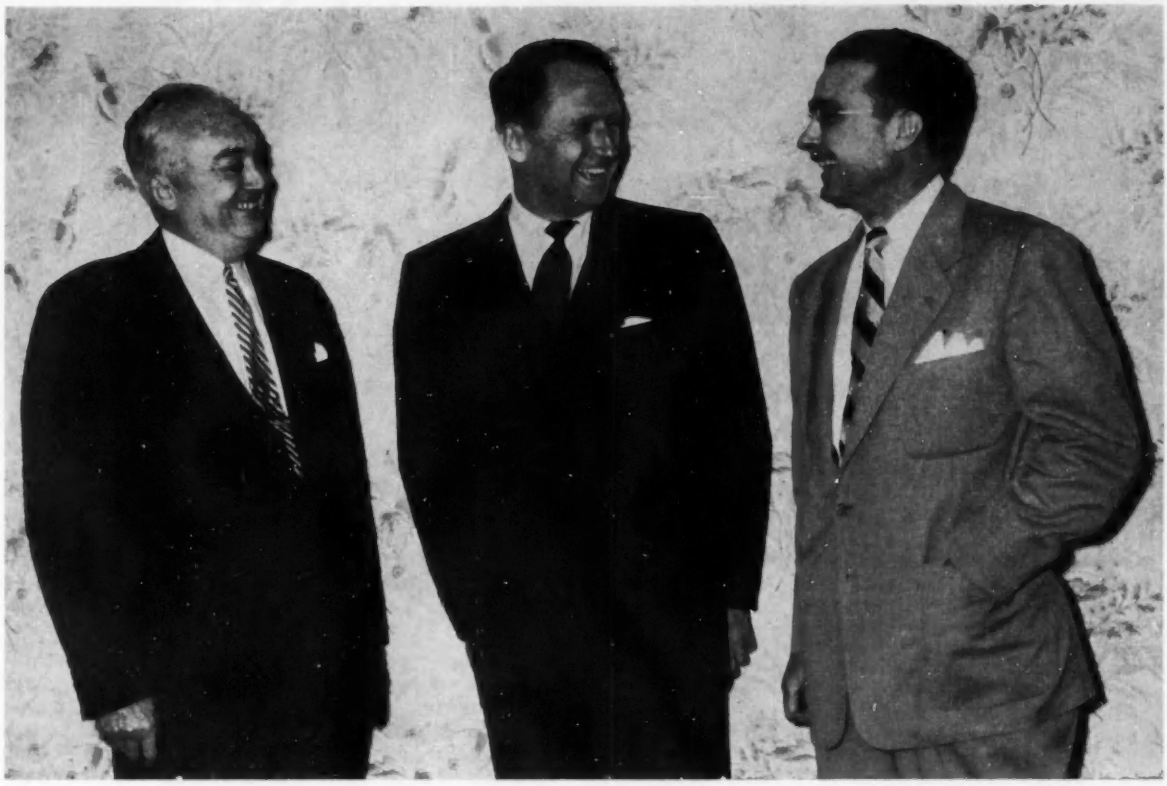
The search for ways to control costs of methods and processes was much in evidence too. For instance, quality control men swapped yardsticks for evaluating costs in their bailiwick. Some said their managements were willing to spend from 1 to 3% of the sales dollar for QC. Another engineer found you're in line if, for every 42¢

Men Who Led the Panels

General Chairman Michael Field (extreme right) briefed the panel leaders on events of the day before start of the Production Forum. Three of the seven leaders shown here are (left to right): R. S. Livingstone, Thompson Products, Factory Personal Relations Panel; K. W. Stalker, General Electric, Improved Manufacturing Methods Panel; and H. V. Beuttell, Republic Aviation, Lead Time and Engineering Changes Panel

After the Production Forum, General Chairman Michael Field (center) reviewed the results with his panel leaders. Leaders here are (left to right): H. H. Hanink, Wright Aeronautical, Metallurgical and Chemical Processing Panel; A. L. Johnson, Bendix Aviation, Quality Control Panel; Chairman Field; A. L. Hegner, Fairchild Engine, Production Control Panel; and F. H. Wittmer, Fairchild Engine, Factory Cost Control Panel

Spread *Economy* Epidemic



Prominent at the Production Forum luncheon were (left to right) Forum Sponsor Roy T. Hurley, who was also toastmaster; Roger Lewis, Assistant Secretary of the Air Force (Materiel), who spoke on "Quality Air Power;" and W. C. Lawrence, General Chairman of the National Aeronautic Meeting

of manufacturing expense, you spend about 53¢ for QC (inspection, testing, and statistical quality control).

Several men in the QC session agreed that gaging and checking equipment is becoming more expensive. But these more costly inspection devices help keep overall costs from moving up.

The Lead Time panel repeated time and again the need for controlling engineering changes if costs are to be kept in line. All discussers agreed that a change board is a must. It's the only way to control a change from inception to production.

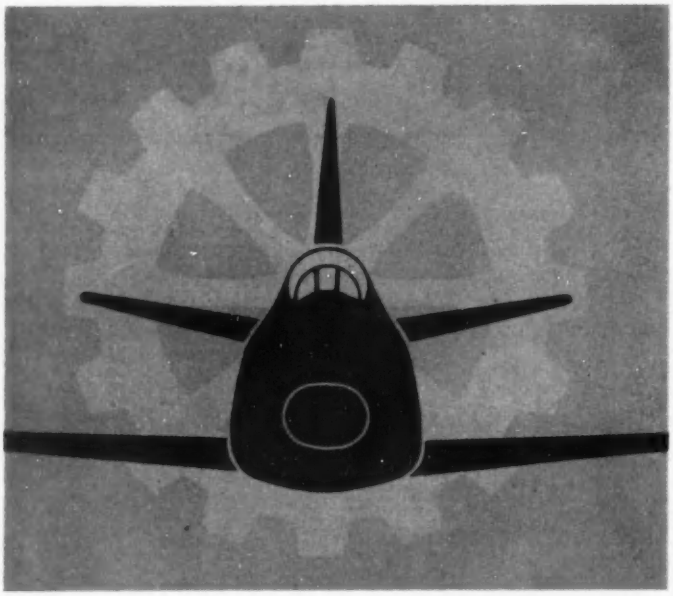
Participants in the panel on Improved Manufacturing Methods focussed on cost saving in fabricating techniques. They heard one man advocate cast steel or iron forging dies, a European development. They pay off for a limited production run. Forge shops should find this a boon, particularly with the unavailability of die sinking facilities.

For large runs, precision forgings were said to bring economies and quality improvement over standard forgings. The engineer in the Metallurgical and Chemical Processing panel who offered this also said quantities have to be large enough to justify precision forgings.

Induction hardening was pointed to as another way of saving forging dollars. It cuts the cost of a forged part by reducing decarb and eliminating scale.

Forging discussions turned to titanium. But few hopeful words were offered here. Seems that forged titanium blades pick up nitrogen and oxygen, both trouble-makers. The blades suffer a loss in fatigue strength and develop greater notch sensitivity.

Titanium was reported to show a little more promise in welding and brazing. But it's too early to know if the material can be processed on a production basis.



Aero Meeting

EFFORTS to make the American jet transport plane a reality were reflected in many papers at the SAE Aeronautic Meeting in New York City on April 13–15.

Of particular concern these papers revealed, is development or refinement of devices to increase the safety and comfort of the new transport planes. In these categories were discussions on:

- Air conditioning.
- Noise control.
- Protection of turbine inlet ducts.
- Reverse thrust.

In addition, one paper described an ingenious method of simulating jet transport operation—the "paper jet" operation. By this simulation, one airline is studying in advance problems it will face in actual jet transport operation.

Air Conditioning

It seems pretty well agreed that the jet-powered transport will not need very different design "end results" from present-day high-speed pressurized transports. So, the air conditioning of the new transports should be based on good, already-well-known practices.

But there is still much to be done to improve present-day air conditioning equipment. Airlines have many gripes about present equipment—and are hopeful that some limitations will be eliminated before the jet transport comes along. They want greater simplicity, lower maintenance costs, and greater reliability, obtained by duplication of equipment, if necessary.

Need for dependability in the cabin pressure control system was emphasized. This system, it was noted, will be more important for the new jet transports than with present aircraft. Loss of cabin pressure at 20,000 ft leaves the crew and passengers several minutes of consciousness without oxygen and an indefinite period of consciousness with it. At 45,000 ft, there is less than one minute of consciousness without oxygen and but a few minutes with oxygen.

Noise

Noise—long a bugaboo of the aviation industry—is still the subject of intense research. As the power of jet engines increases, the noise becomes worse and worse. Thus, high priority is being given to the development of noise suppression devices.

Tentatively, it is considered that the burning noise of a smoothly operating jet does not contribute materially to the total noise. The predominant noise at normal operating speeds is seen to be due, rather, to the turbulent mixing in the free jet. Thus, the jet exit velocity seems to be the most important variable in jet noise generation. This conclusion was reported to have led various investigators to explore devices to reduce the exit velocity. So far, none of these devices appear feasible for flight muffling.

The NACA is sponsoring university research to throw more light on the mechanism of jet noise generation. It is also conducting full-scale tests at its Cleveland Laboratory and model tests at its Langley Laboratory.

Jet Inlet Screens

There seems to be a real need for inlet screens on jet engines. Their purpose is to keep out foreign materials that may damage or completely ruin the engine. The disagreement comes in deciding what sort of device it should be. Should it be fixed or retractible? Should it be permanently installed or

Reveals Progress On U. S. Jet Transport

removable before take-off? How fine should the holes in the mesh be?

For five years protective screens have been required on jet planes delivered to the Air Force, but the matter is still far from settled. The makers and users of future jet transports hope that a satisfactory solution will be found soon. If it isn't, they will also be facing the problem when they start operations with jets.

Inlet screens have a serious effect on engine performance. That's the chief thing against using them. Also, ice can build up on them sufficiently to cause malfunctioning of the engine.

Retractable screens (screens that can be retracted when they aren't necessary or when icing is likely) are being used, but the mechanism is complicated and adds weight.

Entirely new designs are being sought. Gradual improvement of present designs is being attained by trying different materials, fabrications techniques, and aerodynamic configurations.

Reverse Thrust

The purpose of adding reverse-thrust devices to jet planes is to shorten landing runs so as to allow the planes to operate from the majority of existing airports. They thus would perform the same function as the reversible propeller does for propeller transports.

The reverse thrust is attained by diverting the tremendous power of the jet so that it can act as a braking force, on landing.

It was reported that many devices for doing this have been investigated. Some of these are: the half-spherical W, the longitudinal V gutter, the conical V umbrella, the half-spherical U, and the clamshell.

Found most promising in model tests was the clamshell, which, when extended, deflects the flow of gases from the jet-engine tailpipe. It appears that about 45% thrust reversal is possible with jet brakes small enough to fit into the space available near the engine tailpipe.

It is claimed that a jet transport, with normal wheel brakes plus clamshell reverser on each engine, would be capable of stopping in as short a distance on smooth ice as it could on a dry runway with brakes alone.

Simulated Jet Transport Operation

Jet transports are already crisscrossing the United States everyday—in the imaginations of United Air Lines men. They hope to foresee the problems that might be encountered. In this way they may be able to solve them before actual operations are started.

Interest in this operation was displayed by other airlines. It seems that many of them have already

started or are considering similar simulated operations.

Hypothetical simulated flights are "operated" each day in accordance with actual winds, temperatures, and altitudes encountered in normal coast-to-coast flights. Full flight plans are made for each trip and the regular airline dispatchers follow them through the actual traffc patterns.

Typical of the information obtained was that having to do with fuel capacity. Fuel capacity of the hypothetical jet transport studied was found to be more than adequate for operation under present reserve fuel and dispatch policies. It was concluded that jet transports would need no priority if holdover was necessary. Thus, they will be able to take their places with planes powered by piston engines.

All 19 papers presented at the meeting are available in preprint form. Later issues of the *SAE Journal* will carry an abridgment of each paper plus discussion, if any.

Following are several significant statements selected from each paper

Nature of Noise

A sound becomes a noise only as the result of a subjective reaction.

For instance, the majority of us would agree that the sound from the exhaust of a souped-up auto is definitely noise, yet it might be music to the ears of a hot-rod addict. There is also a diversity of opinion in this respect concerning music—it is safe to say that one man's music might be another man's noise. . .

. . . **Adone C. Pietrasanta**, Bolt, Beranek, & Newman, Inc., and **Richard H. Bolt**, Acoustics Laboratory, M.I.T., "Basic Facts about Noise as Related to Aviation."

Propeller Noise

Propeller noise can be reduced materially in turboprop transports through the use of low-rpm, many-bladed propellers.

Even without the use of the "quiet" type of propellers, though, expectations are that the discomfort level from noise (and vibration) will be materially improved in the high-speed turboprop transports visualized. . .

. . . **Joern Schmey** and **Ralph M. Guerke**, Propeller Division, Curtiss-Wright Corp., "Control of Propeller Noise in Turboprop Installations."

Jets Are Noisy

When one works for a time in close proximity to a noisy jet, one becomes obsessed with the idea of stopping the noise by putting things into the jet.

Persons have probably stuck everything but the proverbial kitchen sink into the jet at one time or another in an effort to stop the noise. . .

. . . **Arthur A. Regier**, Langley Aeronautical Laboratory, NACA, "Why Do Airplanes Make Noise?"

Noise Control

Noise control is a negative business. A successful noise control device does not mean greater financial return, but, on the other hand, its neglect can quite easily lead to financial loss through injunction, loss of time, and costly law suits.

The main concern is not to build a bigger and better noise trap but to use the least expensive structure that will do a satisfactory job. . .

. . . **Robert E. L. Fogle** and **Holden W. Withington**, Boeing Airplane Co., "Airplane Manufacturer's Progress with Noise Suppression Devices."

French Aircraft Industry

Before World War II the French aircraft industry was thriving. It was completely self-supporting and was supplying considerable quantities of aircraft to foreign countries.

In June, 1940, aeronautical activity in France was completely stopped. Factories were destroyed; machine tools and technicians were scattered.

After the war, the industry had to overcome this, which was made still more serious on account of the rather radical switch from piston to jet engines. . .

. . . **Benno Grebelsky**, Saint-Cloud Avion Marcel Dassault, "OSP and the Revival of French Aircraft Industry."

Jet Noise—Definition

Four quantities are necessary to define jet noise.

First is the total acoustical output, or power level. The second is the distribution of the sound energy according to frequency, or the power spectrum. The third is the distribution of the energy in space, or the directivity. The fourth is the distribution of energy with time, or the duration of noise. . .

. . . **John M. Tyler** and **Edward C. Perry**, United Aircraft Corp., "Jet Noise."

Turbojet Test Cells

The attenuation requirements for turbojet test cells vary from 20 to 60 db—the lower figure applying to the low frequencies and the higher figure to frequencies of about 1000 cps.

The acoustic treatment of test cells for today's size engines may cost anywhere from $500 to $2000 per db attenuation. . .

. . . **R. O. Fehr** and **B. E. Crocker**, General Electric Co., "Accoustic Design and Performance of Turbojet Test Facilities."

Airport Noise Problem

The NATCC approach to the problem has been two-pronged:

First, we have sought, within the limits of safety and of technological ability, to reduce to an achievable minimum, low, noisy flight over people's homes.

Secondly, we have sought to provide interested residents in airport areas with solid, factual information to help them under-

Continued on Page 71

Wilson on Human Relationships and Technological Progress

After the dinner, the above group of distinguished gentlemen took over (left to right): Earle D. Johnson, president of the Air Transport Association, who was toastmaster for the occasion; Chaplain Richard M. Graham, Lt.-Col. of the USAF, who gave the invocation; Gill Robb Wilson, editor and publisher of Flying, who was the principal speaker; SAE President William Littlewood; and Neil P. Flynn, chairman, SAE Metropolitan Section

IN an eloquent and earnest speech on the place of the engineer in society, Gill Robb Wilson, editor and publisher of *Flying*, stated that the engineer is the backbone of any nation that feels it has a mission to accomplish for the world.

Other points he made in his address included:

- Human relationships and trust have always been important.
- To you, who usually think in terms of formulas and the slide rule, you are taller than you think.
- Technological history is full of cases where there was a failure of men to grasp the significance of the things that had been done.
- Man has made a tremendous conquest over Mach numbers, but our civilization is unable to think through its human relationships to the point where war is no longer a continuing threat.
- I see no solution until we can get things in the proper perspective, until the engineer can also furnish interpretations and can direct his projects in accordance with his interpretations.
- We emphasize the negative phases of security but, at the same time, we neglect such matters as finding ways to train large numbers of our youth in aviation.
- We have our commitments in this world, and we mustn't forget it. Every time we cut back, we'll pay for it. Then we will have to start over again.
- Don't put all the blame on the politicians. We as citizens are to blame. We must be broader in our interests. We must consider the significance of the things we create.

In a short address, President Littlewood said that he is being forcibly reminded of transport safety these days, for everybody asks him what happened to the Comet. He said that American engineers have real admiration for the British for their jet leadership, adding, "There, but for the grace of God, go we."

Now that the accidents have happened, he pointed out, the British are really concentrating their efforts on trying to find the cause. "We do the same thing," Littlewood said. "After an accident we do what should have been done before. We often put a new aircraft into service after what amounts to only casual testing. We don't really try hard enough until trouble occurs."

"We could learn a lesson from the automobile industry in this respect," he continued. "Automobile manufacturers can't afford to put thousands of cars on the road with poorly designed parts, so they test every possible part to destruction at their well-organized, well-manned proving grounds.

"We in aviation must do the same thing," he concluded. "That is, everything that can possibly be proved should be proved to the limit before the plane is put in commercial operation."

Vice-presidents of the Activities that sponsored the meeting get together for a chat. They are (left to right): F. W. Fink, vice-president for Aircraft Activity; R. W. Rummel, vice-president for Air Transport Activity; E. D. Kemble, vice-president for Production Activity; and G. W. Newton, vice-president for Aircraft Powerplant Activity

W. C. Lawrence (left), general chairman of the meeting, congratulates H. R. Harris, chairman of the Display Committee, on his success in gathering the largest number of exhibitors for the engineering display ever attained at an aeronautic meeting

R. D. Kelly (right), chairman of the Board of Award, presents certificates representing the Wright Brothers Award to Z. M. Ciolkosz (left) and D. N. Meyers (center). The recipients also received medals for their winning paper, which was entitled, "Matching the Characteristics of Helicopters and Shaft Turbines." The paper was presented at the SAE Annual Meeting, Detroit, Jan. 14, 1953. It will be published in full in the 1954 SAE Transactions

Continued from page 68

stand and evaluate the air industry's operations from the standpoints of safety, annoyance, economic value, defense value, and the practical aspects of flight. . . . **Vice-Admiral C. E. Rosendahl,** Executive Director, NATCC, "Aircraft Noise Problem in Airport Vicinities—Review of Program and Activities of National Air Transport Coordinating Committee for the Major Civil Airports in New York – New Jersey Metropolitan Area."

Jet Fuel Reserve

Contrary to some opinions, both outside and within the industry, current jet transports are being planned to carry reserve fuel for the same amount of holding time as is customary for present transports.

This means that they will be able to take their place in traffic patterns without preference and will be able to fly to the same alternates as used by other aircraft. . . . **R. D. Kelly** and **H. B. Kaster,** United Air Lines, Inc., "Simulated Jet Transport Operation."

Air Conditioning of Jets

Air conditioning of jet transports will not require far different design "end results" than that required for present-day high-speed pressurized transports.

The definition of a good design is one that excludes the need for extensive modifications to attain basic performance requirements or the need for excessive maintenance. Modifications to attain product improvements are considered necessary, however, to keep abreast of technological developments. . .

. . . **Charles Perry, A. F. Bullard, and O. E. Anderson,** United Air Lines, Inc., "Airline Requirements of Air Conditioning a Jet Transport."

NATO Air Force

By far the most important element in so vast an endeavor as building a NATO Air Force is strict uniformity of purpose, organization, and operation so that NATO can reap the advantages of unified team action.

If the air force of each country were to abide by its former concepts and policies, a weak and

Around the Meeting . . .

Before discussing the subject of jet noise, **J. M. Tyler,** Pratt & Whitney, told about the lady at the zoo who asked the keeper how one can tell the sex of a hippopotamus. "That," said the keeper, "is a question that should be of interest only to another hippopotamus." "But," Tyler added, "we can't put off questions about noise so easily."

Inspirational quote of the week, by **SAE President William Littlewood,** "Wherever knowledge is available, man is capable of solving the problem."

Much credit for the success of the meeting—and the uniformly high quality of the papers presented at the sessions—go to four hard-working gentlemen: **F. O. Hosterman,** meetings vice-chairman for the Aircraft Activity Committee; **R. E. Johnson,** meetings vice-chairman for the Aircraft Powerplant Activity Committee; **W. C. Lawrence,** meetings vice-chairman for the Air Transport Activity Committee and general chairman of the meeting; and **P. A. Miller,** meetings vice-chairman for the Production Activity Committee.

SAE Committee A-9 for Aircraft Air Conditioning Equipment cooperated with the Aircraft Activity Committee to sponsor the Tuesday morning session on air conditioning. Chairman of A-9 is **W. W. Reaser** of Douglas.

Preprints are available for all 19 papers actually presented at the meeting, except for those given at the confidential sessions. Price: 35¢ each to members, 60¢ to nonmembers. Order your copies from SAE Special Publications Department, 29 W. 39th St., New York City 18. The J. L. Allen paper on air conditioning the X-3 supersonic test plane was withdrawn on account of censorship.

Operation of the press room was in the able hands of **A. Sidney Hanson, Jr.,** field engineer for Wright Aero. During the meeting he helped over two dozen members of the press develop stories of the meeting.

Apropos of his hypothetical jet transport operations, **Ray Kelly** related that everywhere he goes he has been hearing rumors that his paper jets have been in accidents. Sometimes it is only a forced landing, other times it is supposed to be a crash. He is always careful to check these rumors. So far, he assured his audience, the rumors have all been baseless. Moreover, session Chairman **Harold Hoekstra** added, the CAA hasn't yet had a single complaint of these paper jets being too noisy.

Corsages for the ladies and boutonnieres for the gentlemen were provided for the dinner guests, compliments of the following international airlines serving New York City: American, Capital, Eastern, KLM, North East, North West, Pan American, Scandinavian, Trans Canada, Trans World, and United. The flowers were flown in from various parts of the world where these airlines operate. Coordinators of this operation were **Dan Beard** and **Florence Starrs** of American Airlines.

Around the Meeting . . .

The final success of a meeting depends, in no small measure, on the smooth handling of the technical sessions. At the Aero Meeting, the following chairmen carried out this assignment with high success:

W. C. Shaw, Hamilton Standard Division, United Aircraft Corp.
Arthur Nutt, Bridegport-Lycoming
Brig.-Gen. B. S. Kelsey, Deputy Director of Research and Development, Headquarters, USAF
F. E. Carroll, Jr., United Aircraft Products Co.
William Littlewood, American Airlines, Inc.
J. Parker Van Zandt, USAF Representative to NATO
E. G. Haven, General Electric Co.
Harold Hoekstra, Civil Aeronautics Administration

SAE members who couldn't attend the meeting benefit from well-written, comprehensive secretaries' reports which record the impromptu discussion that takes place after the papers are presented. For a job well done, SAE is grateful to the following, who served as secretaries:

Vincent Gill, Republic Aviation Corp.
H. O. Fisher, Port of New York Authority
J. D. Redding, Office of Assistant Secretary of Defense (R&D)
O. P. Prachar, Allison Division, GMC
E. C. Marsh, Civil Aeronautics Administration

In accepting the Wright Brothers Award, **Z. M. Ciolkosz** told the dinner guests proudly that just the day before he had been allowed to petition for his American citizenship.

Shush! We can't tell you about the technical matters discussed at the Confidential sessions, but we can pass on the following story told by **Brig.-Gen. Kelsey:**

It seems that a private went to his sergeant to find out what he should do about a cut on his finger. The sarge recommended that he go to the dispensary. The private thereupon ambled over to a door marked "Dispensary."

He walked in and found himself in an empty room, with two doors at the far end, one marked "Sickness," the other, "Injuries." He figured the latter covered his case, so he opened that door, only to find himself in another empty room, with two doors at the far end. These were marked, "Head and Body" and "Limbs and Extremities." He decided a cut finger would come under the latter category, so he went through that door.

Again he found himself in an empty room with two doors. This time one was marked "Major" and the other "Minor." He figured his was only a minor injury, so he walked through that door, only to find himself outdoors. Later the sergeant asked him if he got his finger fixed. "No," he said, "but boy, is that place organized!"

Discussing the use of screens over turbine inlet ducts, **R. R. Higginbotham** of Republic said that the subject made him think of somebody who said that McCarthy reminded him of the small boy who was given a shotgun by a farmer to kill a weasel that was killing his chickens. Later in the day he heard the gun go off, so he went out to the chicken pen to investigate. There he saw the boy holding up a dead weasel and shouting, "I got the weasel, I got the weasel." "Yes," said the farmer, "but you shot most of my chickens, too." "Screens are like that," commented Higginbotham. "Sometimes they catch a 'weasel,' but they kill too many 'chickens.' "

heterogeneous organization would result. . .

. . . **W. H. Ehmann,** Republic Aviation Corp., "MDAP Maintenance and Supply."

Industry Expansion

A problem familiar to all is the eternal dilemma of any sudden expansion—should it be "none today but a flood tomorrow" or "some today and not quite so many tomorrow."

I should be very surprised if your Government is not like the British Government in at least one respect, that it wants some today as well as a flood tomorrow.

. . . **A. F. Kelley,** Rolls-Royce, Ltd., "Some Production Aspects of the Avon Series of Aero Engines."

Turbojet Inlet Screens—Con

The primary objective in the design of turbojet inlet screens is an honorable one—the protection of the engine from such foreign materials as may cause either damage to critical compressor blading or catastrophic failure of the turbojet engine.

Practical design approaches to this problem, so far, have resulted in deleterious factors involving the powerplant that, unfortunately, outweigh any limited success of inlet screens in meeting the objective. . .

. . . **William R. Travers,** General Electric Co., "Factors against the Use of Turbojet Inlet Screens."

Inlet Screens—A Dilemma

Our statistics show that screens lowered the rate of foreign object damage in some cases, while in others there was no apparent difference between the use of screens and no screens at all.

In some cases, failures of a light fixed screen caused more compressor damage than would have been caused had no screen been installed at all. Retractable screen installations showed no conclusive reduction in the rate of foreign object damage. . .

. . . **R. S. Litton,** Air Induction Systems, Powerplant Laboratory, Wright Air Development Center, "Inlet Protection for Aircraft Gas Turbine Engines."

Retractable Inlet Screens

The axial-flow compressor of current military aircraft gas tur-

bines presents an operational problem in that it cannot tolerate very much in the way of foreign articles entering the engine main air stream.

Unless retractable screens continue to be required, their development actively pursued, and their application to aircraft carried out, we will be at a standstill on a serious deficiency in aircraft design. . .

. . . **J. E. DeRemer,** Smith-Morris Corp., "Retractable Air Inlet Screens for Aircraft Gas Turbines."

Jet Reverser

It appears that a practical jet reverser installation can be available in the near future that will give jet planes the operational flexibility enjoyed by present-day reversible-propeller-equipped aircraft.

It will not decrease engine fuel economy and can be adapted to a wide variety of engine installations. Because it is separate from the basic engine, the consequences of reverser failure are considerably less severe than comparable failures of reversible propellers. . .

. . . **Joseph Sutter,** Boeing Airplane Co., "Reverse Thrust for Jet Transports."

Plant Dispersal

The long lines of jigs now in full production at Hawker Aircraft factories could be dispersed within a very short time.

This has been accomplished by designing all our main jigs so that they are erected on rafts made of a structure of rising steel joists welded together and provided with jacking points for leveling up. Thus, in an emergency, we should be able to remove the complete units to a safe area. . .

. . . **E. H. Jefferson,** Hawker Aircraft (Blackpool) Ltd., "Three-Nation Correlated Production of the Hawker 'Hunter' under OSP."

Testing Aircraft Equipment

The necessity for testing will remain until:

- Engineering and engineers have risen to yet unattained levels of proficiency.
- Aviation desires for advancement have slowed down or stopped.
- No limit on the time for engineering calculation and design is specified.

But performance and life cannot be tested into a product—they must be engineered into it.

Important in the urging of a realistic test program is the thought that greater and greater reliance on the test process can result in less and less emphasis on good design, basic engineering, and research.

The aircraft industry cannot afford a trend in that direction. . .

. . . **W. E. Diefenderfer,** United Aircraft Corp., "A Realistic Approach to the Testing of Aircraft Air Conditioning Equipment."

Global Defense

Building military strength capable of resisting communist aggression is the most urgent need of the free nations today.

The global defense system coming into being as a result of our combined efforts is a realistic and hard-headed application of a lesson of history taught by two world wars—that the best security for any one nation or group of nations is to be found in the principle of "unity and strength." . .

. . . **Brig.-Gen. T. P. Gerrity,** Director of Procurement and Production Engineering, USAF, "OSP: Why It Came About and How It Works."

Military Men at Confidential Sessions . . .

A full day of Confidential Sessions (limited to SAE members and military and government personnel cleared for the sessions by the U. S. Air Force) was held on Tuesday. Participants included (left-hand photo): Brig.-Gen. B. S. Kelsey (left), Deputy Director of Research and Development, Headquarters, USAF, chairman of the session at which Major C. E. Yeager (right) told the exciting story of flying research aircraft; (right-hand photo) Lt.-Com. C. O. Holmquist (left), Naval Air Test Center, and Major-Gen. Albert Boyd, Commanding General, Wright Air Development Center, who presented discussions on papers on turbojet engines for supersonic flight by Weldon Worth of the Wright Air Development Center and E. J. Manganiello of the NACA.

Papers were also given at the Confidential Sessions by O. A. Lancaster of the Bureau of Aeronautics, E. C. Simpson of the Wright Air Development Center, H. A. Soulé and W. C. Williams of the NACA, and K. E. Van Every of Douglas

45 Exhibitors Make Engineering Display Huge Success

Aeronautical Service Engineering
Aeroproducts Operations, Allison Division, General Motors Corp.
Aeroquip Corp.
Airtron, Inc.
American Chemical Paint Co.
American Phenolic Corp.
American Steel & Wire Division, United States Steel Corp.
Armco Steel Corp.
Bendix Aviation Corp.
Boeing Airplane Co.
Cleveland Pneumatic Tool Co.
Control Products, Inc.
Durham Aircraft Service
Eastern Industries
Elastic Stop Nut Corp. of America
Fafnir Bearing Co.
Fairchild Engine Division
Franklin C. Wolfe Co., Inc.
General Controls Co.
General Electric Co.
Hamilton Standard, Division of United Aircraft Corp.
A. W. Haydon Co.
Herrmann Engineering Co.
Hi-Shear Rivet Tool Co.
Hughes Aircraft Co.
Keuffel & Esser Co.
Lear Inc.
Lebanon Steel Foundry
Marotta Valve Corp.
Metal Finishing Service
New York Air Brake Co.
North American Philips Co.
Resistoflex Corp.
Rosan, Inc.
Rubber Teck, Inc.
Ryan Aeronautical Co.
S & S Machinery Co.
Speed Control Division, Fairchild Engine & Airplane Corp.
Stratos Division, Fairchild Engine & Airplane Corp.
Sundstrand Aviation
Teleflex, Inc.
Titeflex, Inc.
United Aircraft Products, Inc.
Vickers Inc.
Western Gear Works

EARTH Movers Set the Pace for Progress

Threesome comprises top left, R. M. Smith, general chairman of the Conference; right, R. E. Kennemer, SAE Central Illinois Section chairman; and Lt.-Gen. Eugene Reybold, Banquet speaker. Inset at lower right shows, Keynote Speaker Harald T. Reishus

"EARTHMOVING sets the pace of progress." This first sentence of the keynote address presented by Harald T. Reishus before the Fifth Annual Earthmoving Industry Conference sums up both the past record and the future expectations of the Earthmoving Industry. A record 950 men from all phases of the Earthmoving Industry attended the Conference. Many of them were from the engineering and research departments of earthmoving equipment manufacturers. Others represented sales departments and dealer organizations. Still others spoke for contractors and other users of earthmoving equipment. Representatives of governmental agencies, military services, and universities attended the meetings.

With our present economic uncertainties, one might expect a feeling of apprehension to surround the Conference. No such feeling exists in the Earthmoving Industry. "Progress," described by Mr. Reishus in his keynote address and by Lt.-Gen. Eugene Reybold in his banquet address, was the underlying factor in all of the discussions conducted throughout the two-day meeting.

Mr. Reishus, vice-president of International Harvester Co., described the excellent record of the Earthmoving Industry in the development of our nation. He continued by pointing out the great challenges which lie before the Earthmoving Industry in the future. Earthmoving equipment has done well in repairing our

Sidelines of the Meeting . . .

Jim Symonds says that most speakers have three speeches. The first is what he has written down, the second is what he actually delivers, and the third is what he wishes he had said after it is all over. Equipment builders have the same situation. They have the unit originally designed, the unit they put into production, and what they wish they had built. Fortunately, the equipment builder can change his unit, but the speaker is stuck, once he has delivered his address.

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Lt.-Col. George Coates, Ministry of Supply, Great Britain, heads a British group working on Vehicle Drag Test Codes with problems paralleling those being investigated by Subcommittee XII.

★ ★ ★

The farmer, although not ordinarily thought of as an earthmover, is actually the biggest earthmover in the country. Ken Parks estimates that farmers move 238,000,000 cu yd of earth annually.

★ ★ ★

F. A. Grooss D. K. Heiple Douglas Erskine R. D. Henderson

These Technical Chairmen ran the meetings and directed the course of the program.

F. A. Grooss	—	Caterpillar Tractor Co.
D. K. Heiple	—	LeTourneau-Westinghouse
Douglas Erskine	—	Allis-Chalmers Mfg. Co.
R. D. Henderson	—	Caterpillar Tractor Co.

land from the ravages of floods, tornadoes, and dust storms. In the future, earthmoving equipment can be even more valuable by building protection against the unruly quirks of nature. New and larger sources of energy will be uncovered and exploited through the use of earthmoving equipment. The construction of airports and the improvement of our inadequate highway system will add much to progress.

There is no question that the Earthmoving Industry plays an important role in all types of progress. Meetings of this type are designed to focus attention on a common goal and to combine efforts in the solution of common problems.

The construction and earthmoving industries are characterized by very keen competition. The buyer of earthmoving equipment must assure himself of getting reliable equipment which will assist him in making a success of his operations. Consulting engineer K. F. Parks described a sample comparison between two different machines for use on a specific job. There are many considerations other than the first cost of the machine. Serviceability and availability are prime factors to be considered. Small differences in size or performance may amount to thousands of dollars profit (or loss) during the life of the machine.

One of the biggest problems in the industry is downtime, which was described in detail by J. W. Symonds, of Peter Kiewit Sons Co. The biggest machine with the prettiest paint job won't make any money sitting in the yard or jacked up in a repair shop. There are many things the manufacturer can do to aid in the reduction of downtime. Such cooperation between the manufacturer and the user has been an outstanding reason for the growth and success of the Earthmoving Industry.

Another type of cooperation was described by F. D. Haberkorn. Engineering and Sales work hand in hand to provide the customer with the best machine available for his job. The best design is worthless without a market, and likewise, the salesman would be lost with nothing to sell.

One of the more recent entries in the earthmoving field was discussed by J. B. Codlin of the

Tractomotive Corp. in his paper, "Front End Shovels in the Earthmoving Industry." The front-end shovel or loader is an excellent example of a machine designed by the manufacturer to do a certain job more efficiently and economically. The rapid acceptance of the front end loaders and shovels by contractors and earthmovers proves the validity of the cooperation process between designer, salesman, and user.

K. M. Leech discussed "Engine Requirements for Earthmoving Equipment" based on the experience of his company in providing powerplants for both on-the-highway and off-the-highway earthmoving equipment. There are definite paterns of equipment sizes and powerplant performances which go together. The analysis shows some areas of usage in which new models with a different capacity or performance characteristic might be profitably used.

An outstanding part of the Conference was the Report of CIMTC Subcommittee XII on a vehicle drag test code. The committee, composed of some of the best authorities on the subject, has come up with a practical, workable test code which can give a reasonable evaluation of "reserve tractive ability." The code is the result of serious considerations by each individual on the committee, and reflects the excellent spirit of cooperation typical of committees of this sort.

Lt.-Col. George Coates, from the Ministry of Supply in Great Britain, visited the Conference. Colonel Coates is engaged in test work in Great Britain which parallels that conducted by Subcommittee XII. He expressed amazement at the care and exactness which went into the Test Code developed by the SAE. In his own work, he has been plagued by the difficulty of keeping a test course stable long enough to complete a test, or in being able to reproduce the course for comparative or check purposes. The group which Colonel Coates heads has developed a water stable course which maintains reasonably constant characteristics regardless of weather. Colonel Coates praised cooperation between Great Britain and the United States on such technical matters, and expressed his hope that the two

Sidelines of the Meeting . . .

A young British couple came to the United States and was well impressed by the ingenuity of the American people. Particularly interesting was the small portable car seat for children. The Britisher, wishing to emulate his American cousins, looked for some way to show how sharp he was. He finally placed his young child in a car seat, which he put on his shoulders. While visiting the zoo, the Britisher saw the other children were admiring his youngster's perch. He was feeling very proud of his idea when one little boy stepped up to him, raised his hand in an Indian salute, and said, "How."

★ ★ ★

These men planned and arranged details of the Conference:

R. M. Smith	—	General Chairman
J. W. Carter	—	Secretary
H. Banister	—	Treasurer
E. Brookhouzen	—	Program Chairman
R. H. Williams	—	Publicity Chairman
D. K. Heiple	—	Finance Chairman
J. W. Sydnor	—	Arrangements Chairman

★ ★ ★

Col. George Coates, of the British Ministry of Supply, complimented the manufacturers and users of earthmoving equipment on "actively pursuing perfection in all of your developments and deliberations." To him, the friendly and sincere way competitors worked together on mutual problems was an outstanding testimony to American success.

★ ★ ★

Reference was made to a book entitled "Speaking Can Be Easy for Engineers." Several people suggested another book entitled, "Designing Can Be Easy for Engineers."

★ ★ ★

Two elderly ladies, seeing the abbreviation "SAE" on the hotel bulletin board, were trying to guess its meaning. They finally concluded that SAE meant State Athletic Engineers.

★ ★ ★

Reception preceding the Banquet at the Earthmoving Industry Conference

At the banquet speakers table . . .

. . . were (left to right) Harald T. Reishus, keynote speaker; L. B. Neumiller; R. M. Smith, general chairman of conference; Lt.-Gen. Eugene Reybold, banquet speaker; R. E. Kennener, Chairman, Central Illinois Section; A. F. Meyer, Jr.; and A. C. Boock

nations might continue to work together.

Lt.-Gen. Eugene Reybold, U. S. Army, Ret., highlighted the Conference with his banquet speech entitled "Progress at Its Best." General Reybold listed the many accomplishments of the Earthmoving Industry, the SAE, and the engineering profession, and pointed out that national progress would have been impossible without these activities.

The Earthmoving Industry can well be proud of its past record and if, in the future, it continues with the same earnestness and cooperation, the Earthmoving Industry will help our nation make even greater progress than the best forecasters dream.

The contracting business is one of the most highly competitive fields in our economy, if not the most competitive. Contractors must have equipment which enables them to keep pace with requirements if they are to remain in business and make a profit. To an uninitiated onlooker, there may be little difference between various earthmoving machines, but even little differences may mean thousands of dollars profit —or loss—at the end of the useful life of the machine.

Specific requirements may be summarized like this:

1. Low initial cost.
2. Low fuel and oil cost.
3. Economical and easy maintenance.
4. Proper productivity for job.
5. Easy to operate.
6. High trade-in value.

Careful evaluation of these items along with requirements for a specific job will often lead the contractor toward greater profits and the world toward better living.

. . . "What the Contractor wants in Earthmoving Equipment," by **R. F. Parks**, consulting engineer.

Downtime may be quite accurately defined as time during which machinery or equipment is not being used gainfully or economically. It may be the result of actual machinery breakdown, or it may be from other causes such as operator illness, poor weather, lack of fuel, lack of money, or from many other reasons. Regardless of reason, downtime is costly and is one of the biggest bug-a-boos of the construction and earthmoving industries.

Mechanical breakdown is one item which the combined efforts of the manufacturer, the dealer, the service man, and the contractor can reduce. Machinery design for reduced downtime should keep servicing as a prime consideration. Any changes or improvements which make the equipment easier to service and repair will probably also make the machine more acceptable to the contractor.

Equipment manufacturers should avoid designs which are difficult to assemble correctly. Fool-proof assembly may be idealistic, but the manufacturer should do as much as practical to eliminate parts which can easily be improperly assembled or used.

The cost of downtime shows up in three tangible ways:

1. Cost of repair parts and service supplies.
2. Cost of service and repair labor.
3. Cost of loss of service of equipment involved.

In addition, downtime creates ill will with the contract-awarding agency, lowers employee morale, and increases time spent on the job.

Downtime is costly and its reduction will prove a valuable asset to the contractor and to the earthmoving industry.

. . . "Downtime" by **J. W. Symonds**, Peter Kiewit Sons Co.

Engineering and sales are inevitable partners in the construction and earthmoving fields. It might seem that new designs and improvements would be eagerly accepted by the contractor who needs improved equipment to stay in business. He does not, however, invest tens of thousands of dollars and risk the existence of his business until he is shown the effectiveness of the new product.

When the customer expresses his need for a machine to perform a certain operation in a specific manner, the engineer designs and develops the machine needed, or at least one which will perform the operation somewhat like the

desired machine. Because the practical result of the engineer's work is different from the ideal machine imagined by the buyer, the salesman must enter the picture to bring the two concepts together.

Sales and engineering, in our modern industry of keen competition and high production, will continue to play important roles on the road to progress.

. . . "Engineering—Sales—Progress" by **F. D. Haberkorn**, Caterpillar Tractor Co.

Front end shovels may be divided into two classes. First is the crawler type, generally called shovels since they are best used in excavating as well as loading. Second is the wheel type, generally referred to as loaders, since they work best with stock piles and loose banks.

The development of the front end shovel has included advancement in several fields. The successful front end shovel must be carefully balanced. Power must be matched to the bucket size and capacity. Running gears must be matched to the power. The weight balance of the tractor must utilize the available working energy efficiently. The power in the running gear must be matched properly with the hydraulic energy available to the bucket. The torque converter is an excellent prospect for reducing some of the "power balancing" problems which now exist.

Operator visibility, both of his work and of his movements, has been the subject of much development and subsequent design improvement. The development of accurate and complete bucket control devices has helped the cause of the front end loader and shovel. Major improvements in hydraulic power and control systems have also made a substantial contribution.

Front end loaders and shovels are presently being used in a wide range of applications. Future development and sales effort will make it one of the most widely used and versatile tools of the earthmoving industry.

. . . "Front End Shovels in the Earthmoving Industry" by **J. B. Codlin**, Tractomotive Corp.

In the past 20 years, rapid strides have been taken in the development of mechanized equipment for off-the-highway use. Changes in size, capacity, and speed of this equipment have raised the requirements for engines used in this type of work. Charts of equipment used in various types of hauling show that the gross vehicle weight in lb per hp varies according to the type of work.

The major concentration of equipment in the construction industry falls in the 300 to 450 lb per hp classification. In deep pit mining, vehicles fall in the same range (300 to 450 lb per hp) but there are more models available in the higher horsepower classifications. In shallow pit and strip mining, the gross vehicle weight per horsepower goes well above 500 lb.

Limitations presented by transmissions and the problems of multi-engine installations may be affecting the development of larger and more powerful vehicles. Progress in the development of haulage equipment is being made, and the engine manufactures stand ready to power these new developments.

. . . "Engine Requirements for Earthmoving Equipment" by **K. M. Leech** and **J. A. Watts**, Cummins Engine Co.

Report on Reserve Tractive and Vehicle Drag Test Codes and Comparative Demonstration of Test Equipment Subcommittee XII, CIMTC

Part of the problem of setting up a vehicle drag test code involves actual testing of the procedures and instrumentation decided upon in preliminary discussions. In the development of "Test Code A—Reserve Tractive Ability" three sets of instrumentation were used. Actual test results with the three instrument setups gave remarkably close results. The results were well within the variation considered practical by the committee, in most cases.

The physical make-up of the test code resolves itself into the specification of the test course, a general description of instrumentation to be used, and the establishment of suitable limits of accuracy for the instrumentation, consistent with the accuracy of the results expected. Of course, the procedure for conducting the test and the form for recording and calculating the test results are also specified.

Additional testing and development will prove the validity and accuracy of Test Code A and improve its usefulness in evaluating vehicle performance.

. . . "Results and Evaluation of Field Test" by **P. H. Spennetta**, Caterpillar Tractor Co.

Subcommittee XII was established by the Construction and Industrial Machinery Technical Committee to draw up performance test codes for crawler and wheel type tractors. Procurement agencies for the federal government expressed a keen interest in the development of the test codes and the Corps of Engineers played an important part in testing and development work.

Specific objectives for the test code were to:

1. Be readily understandable by both manufacturer and user.
2. Be reasonably unrestrictive with regard to facilities used.
3. Be repealable and controllable.
4. Be a practical measurement of the performance of test items.
5. Be impartial on equipment within competitive classes.

. . . "The Need for a Test Code and Its Objectives" by **H. L. Rittenhouse**, Euclid Division, General Motors Corp.

Test data are no better than the instrumentation used, and the development of a vehicle test code must necessarily include the development, testing, and specification of instrumentation and its application to vehicle testing. Three different system of instrumentation were used in the tests made during the development of the preliminary codes.

Two approaches may be used in choosing instrumentation for vehicle drag testing. The instrumentation may be as simple as possible to be easily portable and adaptable to many various types of vehicles, or it may be more elaborate to simplify recording and interpretation of data. Each method has its advantages, and the choice in the final analysis must depend upon the accuracy requirements set up as a standard.

. . . "Discussion of Instrumentation" by **Trevor Davidson**, Bucyrus-Erie Co.

TECHNICAL COMMITTEE *Progress*

E-21 Hears Report on Standardization Of Field Overhaul Stand for Turbojets

AMONG the score of matters considered by Committee E-21, General Standards for Aircraft Engines, at its April 6–7 meeting was a report from the Tooling Panel.

The panel has developed a field overhaul engine stand that will fit any of the jet engines in the 10,000-lb thrust class. Basically the device consists of (1) a bottomless rectangular cart having at each end a pair of short rollers mounted longitudinally between cross pieces bridging the cart's sides and (2) two large rings which circle the engine and are fastened to it by adapters.

The rings rest on the rollers, making it easy for the mechanic to rotate the engine to the most convenient position. The length of the rollers accommodates variations in distance between mounting rings among current turbojets.

Tooling Panel Chairman L. B. Hansen reported that his group has worked out dimensions for the turbojet field overhaul stand and is preparing a proposed SAE Aeronautic Recommended Practice on it. The panel is also collecting information for the standardization of a field overhaul stand for turboprops. Both jobs were undertaken at the request of the military services.

Other topics discussed at the two-day meeting were an arithmetic-average surface finish standard, piloted fluid connections of the o-ring type, an engine parts nomenclature guide, thermocouple attachments, control levers, and standard ends for propeller shafts.

Besides the men shown in the photograph, D. S. King of Lycoming, J. H. Borton of Westinghouse, and D. H. Hartmann of Packard are members of the SAE Aircraft Engine Division's Committee E-21.

Committee E-21 Poses During Lull in Deliberations

Members of SAE Committee E-21 at their recent meeting in Washington. Seated (left to right) are V. W. Peterson of Allison, Committee Chairman R. F. Schwarzwalder of Wright Aeronautical, and N. F. Rooke of Pratt & Whitney Aircraft. Standing are D. L. Kidd of Aircooled Motors, H. B. Slusher of General Electric, E. S. Clark who represented D. S. King of Lycoming, and J. C. Squiers of Continental

Front-End Volatility Of Diesel Fuels Studied

THE influence of the front-end volatility of diesel fuels on various engine performance characteristics is discussed in a CRC report, "Front-End Volatility of Diesel Fuels." The characteristics covered include: starting, warmup, acceleration, fast and slow idle, and full-load operation.

The investigation was made because the ASTM asked for information on the technical significance of the 10% distillation point of burner fuels as it affects diesel-engine performance.

Special volatility test fuels covering the 10% distillation point levels of 400 and 500 F and the cetane-number levels of 40 and 50 were used. These fuels were evaluated in four makes of multicylinder and single-cylinder high-speed diesel engines, including both precombustion- and open-chamber types.

The investigation was limited to high-speed automotive engines, as a preliminary survey had indicated that engines of larger bore and slower speed, under the conditions of operation peculiar to their use, were not materially influenced by the front-end volatility of the fuel.

Supplementing the engine test program, the combustion behavior of the front-end volatility test fuels was studied in a constant-volume combustion-bomb apparatus.

Since cetane number was indicated to be very important in determining the behavior of the front-end volatility test fuels in the engine, for academic reasons a brief study was made of the influence of cetane number of the first 10% fraction.

This report (CRC-276) was prepared by the Analysis Panel, Group on Front-End Volatility, Diesel Fuels Division. It is 125 pages, including 25 tables and 36 graphs. It is available from SAE Special Publications Department. Price: $4 to members, $8 to nonmembers.

C. E. Mines Named Chairman Of The SAE Aeronautics Committee

C. E. Mines

CHESTER E. MINES, Allison's chief of engineering services, has been named chairman of the SAE Aeronautics Committee. He succeeds William E. Lawrence of American Airlines, who has been chairman for three years.

Mines was formerly chairman of the Aeronautics Committee's Aircraft Engine Division. He is a member of the SAE Aircraft Powerplant Activity Committee as well as the Technical Board.

Lawrence will continue as a member of the Aeronautics Committee and as its Technical Board sponsor.

The Aeronautics Committee supervises the work of five divisions engaged in standardization and research work. They are the Aircraft Engine Division, the Aircraft Accessories and Equipment Division, the Aeronautical Material Specifications Division, the Aircraft Propeller Division, and the Special Aircraft Projects Division. Close to 400 engineers serve on the divisions and their subgroups.

W. C. Lawrence

Rating Aviation Fuel In Full-Scale Engines

A NEW CRC report outlines research techniques for determining the knock characteristics of aviation fuels in full-scale spark-ignition aviation engines.

The techniques described are meant primarily for comparison of fuels. However, they can also be used with minor deviations to determine fuel requirements of a test engine.

Two methods are described, one of which is more comprehensive than the other.

This method—Method I—provides data which not only permits rating fuels, but which also furnishes a framework for correlating the fuels with laboratory knock-test engines. It involves bracketing the performance of a test fuel between two suitably chosen reference fuels so that a rating of the test fuel may be obtained by interpolation.

Method II, on the other hand, is a simplified means for evaluating the knocking characteristics of aviation fuels in full-scale engines. It involves comparing the knocking characteristics of the test fuel with a single reference fuel.

The techniques described in this report are intended only for agencies skilled in aircraft engine testing.

This report, CRC 275, is entitled, "Research Technique for Determining Knocking Characteristics of Aviation Fuels in Full-Scale Aircraft Engines." It can be obtained from SAE Special Publications Department. Price: 50¢ to members, $1.00 to nonmembers.

Aero Materials Specs Reviewed by Industry

DRAFTS of fourteen SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division. Twenty-nine specifications have been approved recently by the SAE Technical Board.

Copies of all of these specifications are available for review from the SAE Aeronautical Department, 29 West 39 Street, New York 18, N. Y.

The specifications under review are:

- AMS 2403C—Nickel Plating
- AMS 2481B—Phosphate Treatment, Anti-Chafing
- AMS 2485B—Black Oxide Treatment
- AMS 2645C—Fluorescent Penetrant Inspection

Continued on page 112

1954 SAE Technical Board

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About SAE

ELLIS W. TEMPLIN will take over new duties at the Micro-Nut Co., Los Angeles, where he has been appointed director of sales and engineering. The Micro-Nut Co. manufactures precision adjustment wheel bearing nuts. Templin was formerly special representative for the Timken-Detroit Axle Division, Rockewell Spring & Axle Co., Detroit. He was chairman of SAE's Philadelphia Section for 1926–27 and chairman of the Southern California Section for 1939–40. He was an SAE councilor during 1928–29 and in 1944 was vice-president representing the Transportation & Maintenance Activity.

Templin

McGraw

WILLIAM McGRAW has retired as chief engineer of Chrysler Corp. of Canada Ltd., Windsor, Ontario. McGraw has been with Chrysler of Canada since 1929. He was chairman of SAE's Canadian Section for 1937–38, a member of the Council for 1939–40, and a member of the national nominating committee representing the Canadian Section from 1943–54. He expects to travel for a year before considering further assignments.

WILLIAM R. HAMILTON has been elected a vice-president and director of Noma Lites, Inc., New York. He was an advisor on manufacturing and technical problems and for the past year has been responsible for all manufacturing, as well as engineering, and design and development of Noma Lites, Inc.

WILLIAM BERLINER has become project engineer for N. Ransohoff, Inc., Hamilton, Ohio. He was supervisor of production, support-accessory facilities design, for General Electric, Cincinnati.

EUGENE G. HURTER is field service representative for the Curtiss-Wright Corp., Wright Aero Division, Wood-Ridge, N. J. He was formerly foreman of the Pacific Airmotive Corp., Linden, N. J.

ROBERT A. EDMONDS is with the Ford Motor Co.'s Cleveland Engine Plant, Berea, Ohio, as a plant superintendent. Edmonds was previously superintendent of machining for Ford.

B. N. ASHTON, president of Electrol, Inc., Kingston, N. Y., has been elected president of the National Fluid Power Association. He is chairman of SAE Committee A-12, Shock Struts.

Ashton

Teree

B. R. TEREE, chief engineer, Aviation Division, Weatherhead Co., Cleveland, has been elected director of the National Fluid Power Association. Well-known in SAE activities, he is chairman of SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment.

Changes at GMC's Chevrolet Motor Division

Plexico

Flynn

Mair

Farley

Gray

R. S. PLEXICO has been appointed as an assistant chief engineer of the Chevrolet Motor Division of GMC. He will have charge of the truck chassis design section. Plexico was chief truck chassis design engineer for Chevrolet in Detroit.

H. O. FLYNN has replaced Plexico as staff engineer of the truck chassis design section. He was chief aviation engineer at the Chevrolet Aviation Engine Division, Buffalo.

A. C. MAIR is Flynn's assistant. He was previously project engineer for Chevrolet.

NELSON E. FARLEY, JR. is truck chassis development engineer for the Chevrolet Division at General Motors' Proving Ground, Milford, Mich. He was chief chassis engineer for Kaiser-Willys Motors, Toledo.

EDWARD GRAY, former assistant general manager of the White Motor Co.'s Coach and Aircraft Division, Cleveland, and one-time director of Army ordnance development at Aberdeen, has become director of proving ground operations.

Members . . .

G. E. BURKS, director of engineering, has been appointed director of engineering and research for Caterpillar Tractor Co., Peoria, Ill. In his new position, Burks will administer and coordinate all the engineering and research activities of the company, one of the functions previously performed by **H. S. EBERHARD**, president.

Burks

Kanavel

CHARLES H. KANAVEL has been named Western zone manager for the aeronautical sales department of B. F. Goodrich Co.'s Tire & Equipment Division. Kanavel has been Los Angeles district manager and will continue in that capacity for both aeronautical and automotive sales in addition to his new assignment. He will now supervise the activities of the Seattle, Los Angeles, Dallas, and Wichita districts.

RICHARD D. KELLY has been elected a vice-president of The Electric Auto-Lite Co., Toledo. For the past eight years he has been assistant to the vice-president handling the company's original equipment customers.

VINCENT P. MASI is now manager of manufacturing engineering, at the Cleveland Engine Plant of Ford Motor Co., Berea, Ohio. Masi was formerly superintendent of machining operations at the same plant.

GEORGE H. HARRIS has been appointed to the newly-created position of coordinator for the middle district with O. E. Szekely and Associates, Inc. of Philadelphia. His headquarters will be in Dayton, Ohio. Harris was previously with ACF-Brill Motors Co., handling Air Force contracts.

WILLIAM GRANT PONTIS has become senior project engineer for the Delco Products Division of GMC, Dayton, Ohio. He was formerly mechanical designer for Delco.

J. A. DeGRACE has announced the change of name of Garage Equipment & Tools Ltd., Montreal, Quebec, Canada to Equipment, Tools & Steel Ltd. DeGrace is president of the company. There will be no change in the administration nor in the board of directors.

WALTER O. KOEHLER is now associate editor of "Motor" magazine and will be located in New York. He was national accounts representative for the Studebaker Corp., Philadelphia.

FLOYD SNOW is now general manager of L. G. Gildersleeve, Pasadena, sheet metal fabricators and manufacturers. He was general manager of Aero-Cal Engineers, Inc., Burbank, Calif.

WILLIAM A. VAHS, formerly designer for the International Harvester Co. of Canada, Ltd., Hamilton, Ontario, Canada, is now a design engineer, hydraulics, for the Warner Aircraft Division of the Detroit Harvester Co., Detroit.

D. A. PHILBROOK is now methods development engineer, woods department, Oxford Paper Co., New York. Philbrook was with Improved Machinery Inc., Nashua, N. H.

TODD W. FREDERICKS has been appointed Detroit district manager of the Original Equipment Division of Aluminum Industries, Inc., Cincinnati. Prior to his appointment, Fredericks was executive engineer for the Bohn Aluminum & Brass Corp. of Detroit.

GEORGE C. CAMPBELL has been appointed sales engineer for Gemmer Mfg. Co., Detroit steering equipment manufacturer. He was formerly project engineer, sales engineering department, Federal-Mogul Corp., Detroit.

NORMAN R. HOLEN, previously engineer for Kalamazoo Mfg. Co., Kalamazoo, Mich., is now with the McDonnell Aircraft Corp., St. Louis, Mo.

JAMES L. MYERS, president and chairman of the Clevite Corp., Cleveland, has received the Distinguished Service Award from the Cleveland Technical Societies Council for his contributions to the advancement of the engineering and scientific professions.

Myers

Colwell

DR. A. T. COLWELL, vice-president of Thompson Products, Inc., Cleveland, and a past-president of SAE, has been presented with a plaque from the Cleveland Technical Societies Council for his contributions to the success of the Council. Colwell is immediate past-president of the Council.

ROBERT ELLIOT ADEL is with the Consolidated Vultee Aircraft Corp., Fort Worth, Texas, as a test engineer. Adel was formerly at the Buick, Oldsmobile, Pontiac Assembly Division of GMC as a materials and processes engineer and test engineer.

W. G. EVANS, chief inspector of the Williamsport plant of the Lycoming-Spencer Division, Avco Mfg. Co., has been named senior experimental engineer. Evans is chairman of the Placement Committee of the SAE Williamsport Group.

FRANCIS W. KATELEY is application engineer for the Timken-Detroit Axle Division of the Rockwell Spring & Axle Co., Detroit. He was vice-president, engineering, ACF Brill Motors Co., Philadelphia.

Kately

Newberg

W. C. NEWBERG, president of the Dodge Division, Chrysler Corp., has been elected a director of Chrysler. **OWEN R. SKELTON**, former director of engineering, has retired from the board.

WALLACE NEWTON COLLETT, formerly a junior design engineer for The Buda Co., Harvey, Ill., is now a sales engineer for Buda.

JOHN T. BENEDICT, former executive editor of "Design News" magazine, has joined "Automotive News" as engineering editor. He will conduct a new monthly section in the trade magazine on auto engineering, styling, production and materials activities.

MICHAEL ZORETICH, JR. is now service project engineer for the Allison Division of GMC, Indianapolis. He was formerly with A. V. Roe Canada Ltd., Toronto, Ontario, Canada.

A. LINCOLN PITTINGER, consulting engineer, Sierra Madre, Calif., has returned from Europe where he fulfilled consulting engagements concerned with production of munitions under the U. S. Government Offshore Procurement program.

WILLIAM E. SWENSEN, assistant chief engineer, Minneapolis Moline Implement Co., Minneapolis, has been appointed design correlator for the company. He will work on the integration and coordination of tractor, implement and harvesting equipment design for the company.

JOSEPH F. SLOMSKI has joined the Consolidated Vultee Aircraft Corp., Fort Worth, as a senior design engineer in the preliminary design group of the engineering department's technical design section. He was with the NACA Lewis Flight Propulsion Laboratory, Cleveland, as an aeronautical research scientist.

CHRIS NYBERG is now doing product planning and programming for the Tractor and Implement Division of Ford Motor Co., Birmingham, Mich. He recently retired as chief engineer for The Oliver Corp., Plant One, Battle Creek, Mich.

Nyberg

Liggett

ROY BEMISS LIGGETT has joined the Palmer Equipment Corp. in Louisville, Ky., as vice-president. Palmer Equipment is a new corporation just getting set to produce heavy-duty axles and brakes. Liggett was vice-president and chief engineer for Shuler Axle Co. in Louisville.

REGINALD W. PAULEY formerly with the Bell Telephone Labs, Murray Hill, N. J., as a staff engineer, is now studying at Chrysler Institute, Highland Park, Mich.

To be Clayton Lecturer

ROBERT CASS, 1953 president of SAE, has been invited to deliver the James Clayton Lecture by the Institution of Mechanical Engineers, London. A definite date for the lecture has not yet been set, but will probably take place in March, 1955.

James Clayton, a member of the Institution, left money for the purpose of "encouraging mechanical engineering science," and enables the Institution to invite distinguished engineers to give lectures on engineering subjects of their choice.

These lectures are a fairly recent foundation. The first was given in 1947 and of the eleven so far, six have been given by Americans. Carl Rosen, Charles Chayne, and James Bright are SAE members who have been past Clayton lecturers.

WILFRED COLLINS STEWART has become specification engineer, overseas engineering, for Ford Motor Co., Dearborn, Mich. He was technical engineering clerk for Ford Motor Co. of Canada, Windsor, Ontario.

Stewart

Russey

E. S. RUSSEY, president and general manager of the Warner Gear Division, Borg-Warner Corp., has been elected a member of the board of directors of Borg-Warner. He succeeds **J. LESTER DRYDEN,** who has retired after serving as a member of the board since 1929.

CHARLES EDWIN DAVIS is with Shell Oil Co., Martinez, Calif., as a research engineer. He was with Phillips Petroleum Co., Bartlesville, Okla., as a research engineer.

JOHN O. FINDEISEN, JR. is now manager of commercial sales for the Accessories Division of Thompson Products Inc., Cleveland. Previously he was manager of West Coast sales for the same division. He was elected chairman of the Southern California Section for 1953–54.

WALTER L. NORRIS has joined the Pesco Products Division of the Borg-Warner Corp., Bedford, Ohio, as a development engineer. He was formerly chief engineer of The Gabriel Co., Cleveland.

ERNEST W. FULLER has become manager of the Poly-Plastics Division of REF Mfg. Corp., Mineola, N. Y. Fuller was previously director of staff engineering, American Airlines, La Guardia Field, N. Y.

RODERICK A. KEIR is inspector of post primary schools for the Department of Education, New Zealand. He was head of the engineering department of Christchurch Technical College, Christchurch, New Zealand.

THOMAS NEWTON BAKER has joined the Consolidated Tool & Products Co., Los Angeles, as general sales manager. Baker previously was manager of the San Diego office for GMC's Allison Division.

Baker

Daland

ELLIOTT DALAND, a veteran of 37 years as a designer, engineering executive, and manufacturer in the aircraft industry, has resigned as vice-president of Piasecki Helicopter Corp. Daland's resignation will mark only partial retirement. He will continue to actively serve the Piasecki Co. as an engineering advisor.

NORMAN G. SHIDLE, executive editor of the SAE Journal, was a panel member in a discussion on improving the effectiveness of business communications. The panel discussion, sponsored by the American Business Writing Association, was held last month at the American International College, Springfield, Mass.

HAROLD E. VICKERMAN is now a liaison engineer for A. O. Smith Corp., Rochester, N. Y. Previously he was supervisor of the production drawing group for Smith at the Rochester Works.

RALPH M. LEHMAN has been appointed assistant sales manager, Ross Gear and Tool Co., Lafayette, Indiana, steering gear manufacturer. Lehman was sales engineer for Ross.

WILLIAM J. CARTHAUS has become president of the Great Northern Oil Co., St. Paul, Minn. He was previously vice-president, manufacturing and distribution, for the Deep Rock Oil Corp., Tulsa, Okla.

BERNARD ALAN JONES, previously superintendent of service, Information Division, of Ethyl Corp.'s research labs, Detroit, is now superintendent of services, automotive products development, Ethyl, research and engineering department.

D. B. COLYER is a preliminary design engineer for AiResearch Mfg. Co., Los Angeles. He was aerodynamic engineer for Sverdrup & Parcel, Inc., St. Louis.

T. J. AULT has been promoted to the presidency and general managership of the Detroit Gear Division of Borg-Warner Corp. Ault previously was vice-president and assistant general manager of Detroit Gear. In his new post he succeeds **A. P. EMMERT,** who temporarily interrupted his retirement to accept the general managership. Emmert has now returned to retirement.

Ault

Schlarb

H. J. SCHLARB has been promoted to the newly-created position of special representative in the sales department of Chiksan Co. and Chiksan Export Co., Brea, Calif. He was assistant sales manager for Chiksan.

ROBERT L. DOUGLAS has joined Eastern Motor Express, Inc., Terre Haute, Ind. Douglas will be located at Bedford, Pa., where Eastern Motor Express has recently completed a new operational control station and centralized maintenance base. He was equipment engineer, Regular Common Carrier Conference, American Trucking Associations, Inc.

SAE Father and Son

JOHN N. GROMER (M'51), left, and **GEORGE N. GROMER** (M'34) are two enthusiastic SAE members. Gromer senior, general plant motor vehicles supervisor for Mountain States Telephone & Telegraph Co., Denver, sold thirty tickets for the Colorado Group's Ladies Night Dinner and Dance last April.

John, who is sales engineer for Timpte Bros., Inc. in Denver, is the 1953–54 secretary of Colorado Group and was the 1952–53 treasurer.

JOHN H. CALVIN is partner and sales engineer for the Engineering Sales & Service Co., Los Angeles. He was sales engineer for Bendix's Pacific Division.

ROBERT LAKIN, manager of the Detroit branch office of Delco Products, has been promoted to the position of assistant sales manager with headquarters in Dayton, Ohio. **MARK RASPER,** who was supervisor of shock absorber and actuator sales, has been promoted to manager of the Detroit office.

CHARLES RICHTER, formerly sales engineer in the Detroit office, will now serve as supervisor of shock absorber and actuator sales at Dayton.

Kane

FORREST H. KANE has retired from his position as executive engineer at the Pontiac Motor Division of GMC. He had been with Pontiac for over 41 years.

G. S. MASSA has become vice-president of Com-Air Products, Inc., Los Angeles. Massa was formerly vice-president in charge of manufacturing at Hydro-Aire, Inc.

Massa

Hanville

SCOTT H. HANVILLE, JR. has joined Jack & Heintz, Inc., Cleveland, as manager of technical sales. He will be responsible for the prediction of aircraft needs and probable obsolescence of present equipment, for broadening markets of the company's established aircraft product lines and for establishing aircraft development programs most likely to provide maximum business. Prior to joining Jack & Heintz, he was vice-president of engineering for Royal Electric, Inc., Germantown, Ohio.

EDWARD STAWSKI is designer for Allstates Engineering Co., Trenton, N. J. He was thermodynamicist, De-Laval Steam Turbine Co., Trenton.

Obituaries

GEORGE C. LEES

George C. Lees, 73, president and general manager of the United States Axle Co., died April 12.

Lees founded U. S. Axle in 1920. Previously he had been a consulting engineer on axles for Templar Motors Co. and before that consulting engineer for the U.S. Government. He had also been works manager and chief engineer of North American Motors Co., (not now in existence) Pottstown, Pa., makers of gasoline engines for passenger cars, trucks and tractors.

He entered industry as a licensed stationary engineer and later joined National Metal Fabric Co., Plainville, Conn., as a draftsman and superintendent. Still later he was assistant to the general manager of Treadwell Engineering Co., Easton, Pa.

Lees was born in England but was a citizen of the United States. He was a graduate of the Massachusetts Institute of Technology from which he obtained his S.B. degree. He had been an SAE member for more than 35 years.

F. ALEXANDER RIEGEL

F. Alexander Riegel, 50, supervisor of manufacturing information, General Motors Overseas Operations Division, died April 22.

Riegel joined General Motors thirty-two years ago as an apprentice in the Buick experimental machine shop. Later he transferred from the machine shop to the engineering records and specification department. In 1927 he again transferred to General Motors Export Division.

Surviving are his wife, two sons, a daughter, and brother.

HARRY L. KELLER

Harry L. Keller, manager of sales, Mahoning Designers, Inc., Youngstown, Ohio, died April 8. He was 67.

Prior to joining Mahoning Designers, Keller was with Buick Motor Co., Flint, Mich. He had been with Buick since 1921, except for a two-year interval when he was designer for the Oakland Automobile Co., Pontiac, Mich. At Buick he began as a checker, became a drafting room supervisor, and then motor engineer. Later he did chassis unit engineering, material control, research engineering, and production of war products.

Before he joined Buick, he was a designer for Overland Automobile Co., Pontiac, Mich., Motor Transport Corps., Washington, D. C.; and Owens Bottle Machine Co., Toledo, Ohio.

Born at Bowling Green, Ohio, Keller attended grade school and high school in Fostoria, Ohio. He later attended night school to study engineering.

Besides SAE, he was a member of the American Society for Metals.

HARRY S. RICHER

Harry S. Richer, 44, project engineer, Bendix Aviation Corp., North Hollywood, Calif., died March 10.

Richer had a great deal of tool design experience working for the Studebaker Corp. in Chicago; Lockheed Aircraft Corp., Burbank, Calif.; Union Special Machine Co., Chicago; South Bend Tool & Die, South Bend, Ind., Caterpillar Tractor Co., East Peoria, Ill.; Acme Machine & Tool Co., Chicago: and Midwestern Tool Co., Chicago. At one time he conducted his own engineering business, Richer Engineering Co., Chicago.

He was born at Waterbury, Conn., and studied at the Lewis Institute, Chicago. His other memberships included the American Society of Tool Engineers and the Engineers and Architects Association.

P. A. WATSON

P. A. Watson, 73, retired production engineer, died February 26.

Watson had a variety of experience as general foreman for Gemmer Mfg. Co., Detroit; assistant chief inspector, superintendent, and general foreman of the Motor Division of Packard Motor Car Co., Detroit; superintendent and factory manager of the Rutenber Motor Co., Marion, Indiana, and production engineer for Auburn Automobile Co., Auburn, Indiana.

He was a member of SAE since 1917.

STEPHEN VORECH

Stephen Vorech, new development design engineer for Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio, died February 22. He was 60.

Vorech joined Westinghouse Electric Corp., East Pittsburgh, Pa., as a machine hand when he first came to this country from Czechoslovakia in 1915. For a while he worked for the Union Switch & Signal Co., Swissvale, Pa. In 1918 he became a naturalized citizen and entered the U. S. Army in the same year. He was a sergeant in the engineering corps.

When he finished his Army service, Vorech joined Westinghouse Air Brake Co., Wilmerding, Pa., again as a machine hand and soon became a draftsman. Later he was made chief draftsman. He continued with the company and was new development design engineer for the company at the time of his death.

Vorech attended trade school in Czechoslavakia where he studied mechanical drawing, shop practice and accounting. When he was fourteen he became an apprentice and then a journeyman for the Kolben Co., Czechoslovakia. He also worked for the Prague Steel Co., Czechoslovakia, before he came to the United States. While at Westinghouse Air Brake Co., he studied mechanical engineering at Westinghouse Tech, Turtle Creek, Pa.

ROYCE G. MARTIN

Royce G. Martin, president and chairman of the board of The Electric Auto-Lite Co., died of a heart attack May 1 in Lexington, Ky. He died only minutes after his horse Goyamo, finished fourth in the Kentucky Derby.

Martin was born in Clint, Texas in 1884. After attending St. Patrick's and St. Aloysius Academies, he became an apprentice for the Western Electric Co. in Chicago. Later he worked in the tool shop of Felt & Tarrant Co., makers of marine motors.

In 1909 he returned to his native Texas to work for the Mexican National Railroad in El Paso. He became president and general manager of the Automobile Mortage Corp. of Texas after World War I. In 1921 he assumed control of the Safe-T-Stat Corp. in Brooklyn, a manufacturer of visual thermometers for automobile radiator caps.

In subsequent transactions, Safe-T-Stat acquired the entire capital stock of the Nagel Electric Co. of Toledo and absorbed the Moto-Meter Co. of Long Island City, N. Y., and the National Gauge and Equipment Corp. of La Crosse, Wis. The corporation was named the Moto-Meter Gauge and Equipment Corp., and Martin served as President and director.

Martin became president of The Electric Auto-Lite Co. in 1934 when Moto-Meter and Auto-Lite merged. He succeeded to chairman of the board in 1944 after the death of C. O. Miniger, founder of the firm.

Under his leadership, Auto-Lite's annual sales grew from about $34 million in 1934 to nearly $300 million in 1953. He was instrumental in channeling Auto-Lite's production facilities into other non-automotive fields.

Martin was active in community, church and fund-raising affairs in Toledo and Lexington. He also served on many industry committees, and was an active member in the Toledo Chapter, Automobile Old Timers.

from the Sections

A chain of diesel reports has been flowing in from the North, South, and East. Of particular interest is Milwaukee Section's report on a radial engine built as an oil-burning diesel-engine, a spark-ignition gas engine, or a dual-fuel engine. For more about diesels see Pittsburgh, Texas Gulf Coast and Cincinnati Sections.

Montreal

Field Editor
P. E. Falkner
Apr. 19

A BEARING THAT WILL RUN 250,000 MILES before overhaul is necessary, was revealed by John McHugh at this meeting. McHugh is chief engineer of Leyland Motors (Canada), Ltd.

Low rate of wear for the bearing, which is copper-lead on steel backing, is partly due to its use with **nitrided forged-steel crankshafts.** These are "vastly superior" crankshafts, insofar as fatigue strength is concerned.

The bearing runs 250,000 miles only if the lubricating oil supply doesn't fail and if there is no water mixed with the oil. Further bearing improvement can be obtained if the surface is treated with an electrically deposited **skin of indium,** thermally infused into the lead.

McHugh told members these facts are the results of tests at Leyland Motors.

Northwest

Field Editor
W. M. Brown
Apr. 9

MECHANICAL DEFECTS CAUSE A SMALL PERCENTAGE OF ACCIDENTS, according to ICC statistics. Stephen Johnson, chief engineer of Bendix-Westinghouse Automotive Air Brake Co., pointed out that 6.47% of 25,889 accidents were due to mechanical defects. Of these, 40% were attributed to brakes.

These figures come from the November '51 report of the Section of Safety of the Bureau of Carriers, ICC. This covers the analysis of mechanical defect accidents for 1950.

The principal cause of imperfections was lax and **improper inspection** and maintenance or absence of such. Johnson said that practically all brake **accidents were preventable** and that the means of prevention were not expensive, complicated or burdensome.

Central Illinois

Field Editor
W. J. Lux
Mar. 22

COLLEGES ARE DOING AN EXCELLENT JOB in preparing men for engineering careers, according to panel members at the March meeting.

It was agreed that loud complaints about inadequate college training come from educators themselves. Shortcomings which some critics write into engineering education are more likely to be the fault of the student rather than the material or the way it is presented.

A grave mistake a graduate engineer can make is to enter industry with the feeling that his training has been completed. **A good engineer's training** is never completed.

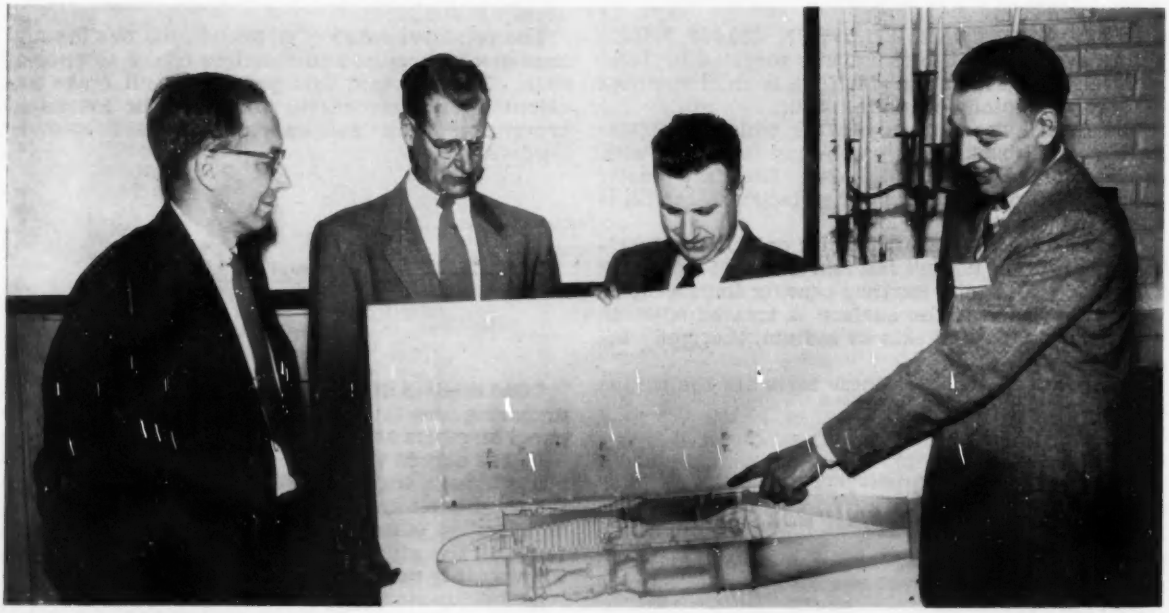
Panel members believed that most companies are

From Section Cameras

Western Michigan (Apr. 20)

Presenting his paper, "Marine Engines," is Paul A. Engstrom, chief engineer of Gray Marine Motor Co., Detroit.

Twin City (Apr. 14)



Studying schematic drawing of a turbojet engine are: (left to right) Chairman Newman A. Hall; Speaker William Swenson, design correlator, Minneapolis-Moline Co.; Vice-Chairman Donald J. Breining; and Speaker Lloyd Berggren, senior project engineer, Minneapolis-Honeywell Regulator Co.

anxious to take young graduate engineers into their organizations and give them the background necessary for advancement. In fact, general opinion was that the best way to get from college to industry is to look for **training programs.**

As for **changing jobs**—do it early. This is the advice of leading engineers and management people. However, graduates were warned to avoid the label, "professional drifter." Changes should be few, but early.

Further advice was that the engineering profession provides **a stepping stone** to other fields. Sales departments are hiring more and more men with engineering background. As our lives become more mechanized, engineers will become increasingly important in all types of work.

Western Michigan

Field Editor
B. W. Rollin
Apr. 20

". . . **EVERYBODY WANTS TO GO FASTER** and faster, and I see no end to the trend." These are the words of Paul Engstrom, chief engineer for Gray Motor Co. Engstrom presented his paper, "Marine Engines" at the April meeting.

"Naturally, we are going to cooperate with this demand if it kills us. Currently, I am personally deeply involved in the development of two series of engines aimed at satisfying this demand. I think a few design features of one of these engines will be of interest to you.

Horsepower—well over 200
Rated rpm—3400 to 3600
Displacement—427 cu in.
Compression ratio—7.2/1
Cam timing—20-22-57-63
Valve lift—0.460
Water heated dual intake manifold
Weight per hp—6 lb

"Some of you may remember when the Harmsworth Trophy was won with a sensational 25 mph and the driver shook for a week. The current record for unlimited hydroplanes is over **178 mph.**"

Engstrom said that **gasoline economy** is not regarded as very important. While the specific fuel consumption of marine engines is comparable to other engines, it is a generally accepted fact that prolonged operation at high power output will eventually consume a gallon or two of gasoline. The same remarks apply to oil consumption.

San Diego

Field Editor
F. C. Heinig
Apr. 14

SAN DIEGO'S FIRE DEPARTMENT PROLONGS ENGINE LIFE by dispensing with the customary morning warm-up. That's what Robert Ely, battalion chief in charge of the department repair shop told Section members.

"For years the San Diego Fire Department wore out its **equipment testing** to see if it would run," he said. Six years ago he persuaded the department to give up the morning testing period.

"Since then only once has an engine failed to start when the alarm sounded. Not bad for **32,712 starts.**"

Ely believes the average two fire calls that San Diego engines go on every day give the apparatus all the exercise it needs.

"An engine deteriorates more in the first five minutes than in the next hour," he said.

Pittsburgh

Field Editor
O. B. Rosstead, Jr.
Apr. 27

FIFTY PER CENT MORE POWER is developed from today's diesel engines as compared to their predecessors of 15 years ago. Spurred by ever increasing industrial and automotive power demands, engine designers have succeeded in extracting, year after year, **more output** from the same cylinder displacement. This is what H. M. Gadebusch of GMC's Detroit Diesel Engine Division told members.

He said, too, that today's diesels possess twice as long an operational life. Gadebusch calls diesel-engine construction "an art"—not a science.

". . . Just as every new engine design provides new lessons for its originator, so will every new engine application pose some problems for the operator. Different types of motorized equipment show such wide variations of normal work cycles that the resulting temperature conditions, aggravated by seasonal changes, cannot always be accurately predicted by an engine manufacturer."

Gadebusch warned that, though it is true a diesel engine "will burn anything," fuel characteristics determine how long the engine will operate satisfactorily. Of interest to those who have had **starting troubles** in cold weather is the fact that for every 10-deg drop of air temperature, the compression temperature is lowered by 23-deg F. Thus a 50-deg air temperature drop causes a 115-deg compression temperature drop.

Hawaii

Field Editor
R. G. Deemer
May 3

1700-FT INSIDE THE KOOLAU MOUNTAIN RANGE, Section members heard a report on the Wilson Tunnel project by Frank Peters. He is general superintendent of Gibbons & Reed Co., Salt Lake City, subcontractor for boring the tunnel.

Wilson Tunnel is being built to relieve the **highway congestion** that prevails in Hawaii. It will be the second link between Windward Oahu and Honolulu proper.

After the inspection, members adjourned to the Thailiana Hotel where a report was given by the Territorial Highway Department's resident engineer, Sam O. Hirota. Hirota explained that cessa-

From Section Cameras

Milwaukee (May 7)

Dining before the technical session are enthusiastic Milwaukee Section members. At the speaker's table in the background are: (left to right) Leo Lechtenberg, F. J. Hartshorn, P. F. Allmendinger, H. M. Wiles, R. L. Switzer, F. B. Esty, Lloyd L. Bower, Robert Cramer, C. L. Spexarth, A. W. Schaper, J. W. Mohr, D. R. Neeld, E. H. Panthofer, Dean G. Thomas, Igor Kamlukin, C. H. Duquemin.

All smiles at Milwaukee's May meeting are: (left to right) Robert Cramer, assistant chief engineer, Nordberg Mfg. Co.; Speaker A. W. Schaper, senior product designer, Nordberg; and Field Editor D. Roger Neeld, supervisor, Heavy Machinery Division, Nordberg.

Southern New England (Apr. 6)

The Navy's needs in aircraft engine design was the subject of J. Denny Clark (center) of the Bureau of Aeronautics. To Clark's left is Technical Chairman Gilmoure N. Cole, and to his right is Section Chairman L. Morgan Porter.

tion of the Wilson job came about on several occasions because all equipment had been rendered immobile in mud. This was a continual problem encountered by the contractor E. E. Black, Ltd. of Honolulu. He said special emphasis is now being given to the **construction equipment** used.

Slides showing day-by-day progress were shown.

Twin City

Field Editor
S. H. Knight

Apr. 14

THE DILEMMA OF THE CONTROL MANUFACTURER is what appears to be conflicting needs. On one hand, he is pressed by the user for smaller and simpler controls. On the other, the engine manufacturer is making engines so complex, controls naturally tend toward complexity. This is what Lloyd Berggren, senior project engineer, Minneapolis-Honeywell, told the Section.

Berggren thinks complex problems are most easily solved by electrical circuits. It is quite certain, he believes, that **hydraulic-mechanical** controls will continue to find extensive use where problems are simpler. Minneapolis-Honeywell is developing both types.

A trend toward **electric motors** in the oil fields as pumping engines was discussed by W. E. Swenson at this meeting. He is assistant chief engineer of Minneapolis-Moline.

Swenson said that excessive maintenance costs of the internal-combustion engine has brought about this trend. In the Williston Oil Basin, where temperatures are extreme, **a new challenge** has been offered to internal-combustion engines.

Water-jacketed basin pans seem to be the answer to engine operating and oil sludge conditions. These control temperature of the lube oil, regardless of ambient temperatures. **Built-in floats** in the base pan and the use of external fuel tanks permit engines to operate for a long period without attention.

Also, **automatic control of** temperature and oil pressures, as well as pressurized cooling systems, using ethylene glycol, have proved very satisfactory. Prepacked antifriction bearings with synthetic greases have eliminated Zerk fittings and periodic lubrication.

Detroit

Assistant Field Editor
D. T. Roberts

Mar. 15

THE MAJOR PROBLEM IN TURBINES is the temperature limits imposed by insufficient knowledge of metallurgy. At the Junior's dinner-meeting, Donald Frey of Ford's scientific laboratory predicted that a ferrous-nonferrous alloy will give the best combination of **ductility and strength** at extremely high temperatures.

Frey believes, too, that compressor wheels can be cast in one piece of aluminum alloy, if stresses are kept within reasonable limits.

The use of a heat exchanger to boost economy under partial loads was emphasized by Charles Amann of GMC's Research Laboratories Division. Amann explained differences between actual and theoretical **thermodynamic cycles** of gas turbines. A split shaft engine in which the power turbine and gas producer sections are separated to obtain maximum torque at low speeds was also discussed by Amann.

The Palouse and the Artouse engines and their uses as auxiliary engines to operate aircraft starters and other accessories in small aircraft, were described by Fay Roepcke, research engineer at Continental Aviation and Engineering Corp.

Color movies of the **latest Pan-American Road Race** were presented by the assistant manager of Lincoln-Mercury product planning, Joseph Gillette. Gillette stressed the necessity for teamwork in modern road racing for successful competition.

Apr. 27

FOR COLD-ROLLED STEEL, hot-rolled strips should be reduced in thickness by 45% in order to reduce grain size and obtain a **good homogenous structure.** This is just one of the facts learned when Detroit's Junior members toured the Great Lakes Corp.

Another fact of interest to the Juniors was that in the finishing operation at the cold-rolled mill, smooth steel is made rough. This is done to make paint adhere.

One-hundred-ninety-five Juniors viewed the 18 open hearth furnaces, the hot rolling mill, the cold rolling mill, and the **coiling operations** at both mills.

Wichita

Field Editor
W. E. Shelor

Apr. 21

MONEY ALONE LIMITS PROGRESS in inspection control of structural casting. This was the general opinion of the speakers at the Section's Symposium of Close Tolerance Castings.

It was thought that the need for complete inspection control is common on any structural casting and that present inspection procedures should progress with industry. **X-ray and metallurgical control** is necessary, but better and faster methods of positive inspection must be developed.

Speaking about the Osbrink process, Dick Saunders, president of Saunders Castings, Inc., Wichita, said that because of the cost of tooling, which usually controls the degree of close tolerance, **unreasonable requirements** should be eliminated and used only when necessary.

In presenting the Permafuge Process, Jack Hall, representative of Wheelcraft Corp., Azusa, Calif., said personal enterprise has resulted in improving casting methods and materials, speed in production, and large cost savings to the consumer for quantity production.

"Investment Castings" was presented by Charles Chisholm of Haynes Stellite Corp., Kokomo, Ind. Chisholm pointed out the fact that close tolerance

From Section Cameras

San Diego (Apr. 14)

He doesn't chase fires . . . but he sees to it that San Diego's firemen do. He is Robert Ely, batallion chief in charge of the San Diego Fire Department's repair shop, who was speaker.

(Detroit Mar. 15)

The present and the future of the small gas turbines were discussed at a panel session staged by Detroit Section's junior members. Panel participants were: (seated, left to right) Donald Frey, metallurgical department head, scientific laboratory, Ford Motor Co.; Charles Amann, senior research engineer with General Motors' Research Laboratories Division, and Fay Roepcke, research engineer at Continental Aviation and Engineering Corp. Consultants at the panel session were: (standing, left to right) O. E. Rodgers, chief engineer of Packard Motor's Jet Engine Division; Prof. F. L. Schwartz, mechanical engineering department, University of Michigan; W. A. Turunen, head of GMC's gas turbine department, Research Laboratories Division.

castings are the result of an effort to reduce machine work, to reduce weight, and to reduce the cost of the finished product.

Cleveland

Field Editor
W. B. Fiske
Mar. 14-Apr. 12

"EDUCATED GADGETS" was the theme when Cleveland Section members appeared on the TV series, "Adventures in Engineering," Mar. 14. This series is sponsored by the Cleveland Technical Societies Council.

SAE members told the TV audience that when a need is recognized, engineers go to work and develop accessories to meet the need. The **engineering progress** that has been made in the gadget field was demonstrated by exhibits. Speedometers, fuel gages, carburetors, and many other items were discussed.

Adding glamour to the show was Betty Fathauer, woman engineer and SAE member. John Stirling of Ford Motor Co. was chairman of the TV committee and moderator of the program.

Student members of Case, Fenn, and the General Motors Institute all got together at the 1954 Student Banquet March 22. Maurice Olley, director of research and development at GMC's Chevrolet Motor Division, presented "The Evolution of a Sports Car —the Chevrolet Corvette." **A toy model of the Corvette** was presented to Olley by the students of Fenn and Case in appreciation of his address.

Top social event of the season was the Annual Ladies Night Dance, April 10. Cocktails, dinner, dancing, gifts, and just a good-time was the order of the day. Success of the "biggest and best" dance is attributed to the dance committee: T. R. Thoren, A. D. Gilchrist, J. P. Henson, Walter Luli, Ned Brown, and the ladies who assisted.

At the Section's April 12 technical session, "Engineering the Ohio Turnpike" was presented by Theodore J. Kauer. Some facts of interest were:

1. The pike will be made of 10-in. reinforced concrete on 6-in. water-proof sub-base, capable of withstanding **a 36,000 lb axle load.**
2. A radio system with micro-wave relay towers, will be employed in policing the system, and **automatic recording devices** will be used at the terminals.
3. The separation strip will be extremely wide for safety's sake, and **luminous painted lines** will be used to mark the highway.

Texas Gulf Coast

Field Editor
W. B. Tilden
Apr. 2

AN INCREASE IN QUANTITY OF QUALITY DIESEL FUEL is one advantage of using amyl nitrate according to Edwin A. Desmond, manager of the diesel section of Ethyl Corp.'s Technical Service Division. Desmond said that the practicality of the diesel ignition improver has been amply proved in the laboratory and in the field.

Among its other advantages, he listed:

1. An **increased flexibility** of refinery operations by reducing the need for controlling the natural cetane number of middle distillates to make diesel fuels.
2. The choosing and blending of diesel-fuel components from the standpoint of other desirable characteristics such as volatility, high volumetric heating value, and low pour point by providing another means of **meeting cetane requirements.**
3. Considerable savings in some circumstances by consolidating the blending, distribution, and storage of diesel fuel and furnace oil into a single product that would be satisfactory as a burner fuel as blended, and would be made into a good diesel fuel by raising the cetane number to the desired level by adding amyl nitrate at the marketing point.

Milwaukee

Field Editor
D. R. Neeld
May 7

A RADIAL ENGINE BUILT AS AN OIL-BURNING DIESEL ENGINE has been created by Nordberg Mfg. Co. It can be built as a spark-ignition gas engine or a **dual-fuel engine** as well. That's what A. W. Schaper, senior product designer for Nordberg, told the Section.

Besides its adaptability to various power applications Nordberg's 2-stroke engine is **most revolutionary** from the standpoint of compactness, simplicity of design and perfect balance.

Another interesting fact is that the **unusually designed crankshaft** has only one throw. It is of two-piece construction made of high tensile alloy cast iron.

Cincinnati

Field Editor
E. B. Lohaus
Apr. 26

THE AUTOMOTIVE DIESEL IS HERE TO STAY ". . . for a long time . . . for so long as operating economy remains a desideratum of operators." This is the opinion of Merrill C. Horine, Mack Truck Co.'s consulting engineer.

Horine also said, however, that it is one thing to say the diesel is here to stay and quite another to predict it will supplant other sources of power.

". . . Steam did drive sails out of commercial shipping. The motor vehicle has practically supplanted the horse. The diesel locomotive has all but replaced the steam engine. The motor bus has nearly completed the ousting of the street car. But—

"The airplane has not quite relegated lighter-

Cleveland (Mar. 14)

Television stars are John Stirling (left), chairman of the Cleveland Section's Television Committee; and (right) Ned Brown, Section chairman. In center is Paul Bedford, the station's announcer. Stirling and Brown appeared on one of a series of programs sponsored by the Cleveland Technical Societies Council.

(Apr. 12)

Speaker Theodore J. Kauer, chief engineer, Ohio Turnpike Commission, presented some interesting facts in his paper, "Engineering the Ohio." W. C. Johnson, vice-chairman of the Akron-Canton District of Cleveland Section planned the meeting.

Kauer

Johnson

(Mar. 22)

In the huddle are Speaker Maurice Olley (center), director of research and development at GMC's Chevrolet Motor Division; and (left to right) John Coffin, assistant metallurgist at Chevrolet, speaker's assistant; Chairman E. K. Brown; Olley; Past SAE President A. T. Colwell; and Prof. James Jeromson of Case Institute.

than-air craft to limbo. Turbines have far from eliminated reciprocating engines either in steam or gas. The radio has not obsoleted the phonograph nor has it been supplanted by television.

"Likewise, **the diesel will serve side-by-side** with the gasoline engine for as long as we can foresee."

Mohawk-Hudson

Field Editor
L. F. Smith
Apr. 13

THIRTY-TWO OUT OF THIRTY-THREE cars entered in the '53 Indianapolis 500-mile race had Offenhauser engines, according to Robert I. Jackson of the Perfect Circle Corp.

Jackson told members that this basically simple engine has been developed to about **400 hp.** The compression ratio is usually between 10 and 15. He also described the differences between the **Kurtis-Craft 500 A,** which won the race and the 500 B.

More than 50 color slides showing **basic design** of various race-cars illustrated his talk.

Philadelphia

Field Editor
Paul Kennedy
Apr. 14

THE 100,000-MILE TRUCK TIRE is now available for over-the-road service, thanks to cooler-running synthetic fibers. M. F. Torrence, manager of Du Pont's Akron laboratories said that a blend of natural rubber, **GR-S, and neoprene** in truck tire treads might overcome the problem of tread cracking. This is because the stronger rayon and nylon fabrics allow thicker (and, therefore, hotter-running) treads.

Synthetic rubber has **saved the consuming public** of this country an amount in the billions of dollars, he claimed, and he also pointed out that synthetics have stabilized the market price, freed us from **dependence on foreign supplies** of natural rubber, and most significant to the consumer—have increased tread life and abrasion resistance.

Tubeless tires for trucks will come, he said, weighing less than present types because both the tube and flap are eliminated. Heat build-up will be less and cost will be lower, Torrence told the section.

Washington

Field Editor
C. Janeway
Apr. 20

FROM 1187 NONSTANDARD TO 59 STANDARD PARTS was the result when the Army Engineers decided to reduce the number of parts used in military equipment. This is what Col. C. T. Newton, director of research and development, Corps of Engineers, told members.

Through the cooperation of private industry, the Corps of Engineers has reduced the number of service engines in the 2⅞-in. to 4⅛-in. bore class from 19 to 5. This brought about the remarkable reduction of **high mortality spare parts** from 1187 to 59. Engine standardization, the first step, has now been followed by standardization of engine accessories.

Dayton

Field Editor
P. J. Long
Apr. 15

A TOUR, A DINNER, A FILM, AND A SOCIAL half-hour were all sponsored by the Denison Engineering Co., Columbus. Denison produces a wide selection of hydraulic presses, an extensive line of hydraulic pumps and controls, and other hydraulic equipment.

Victor V. Blasutta, vice-president and director of engineering at Denison welcomed the Section and then Cecil Adams, chief research engineer, gave a talk on "The **Design of Multipress Valves.**" "Design Features of the Denison Vane Pump" was presented by John R. English, project engineer on vane pumps, and a sound film, "Multipress and How You Can Use It" was also shown.

Williamsport

Field Editor
P. Cervinsky
Apr. 5

THE PRIMARY CAUSE OF PREIGNITION in modern automotive engines is combustion-chamber deposits, according to Donald Diggs. Diggs is with E. I. du Pont de Nemours & Co.

Deposit-induced preignition **may be silent,** Diggs warned, or it may be manifested by a variety of engine noises ranging from light pings to violent explosions. The ability of deposits to induce preignition arises from localized high temperatures, which are developed through the combustion of carbonaceous material in the deposit structure. The burn-off of **carbonaceous material** is promoted by the salts of lead and other metals and is influenced markedly by engine conditions.

The fact that some hydrocarbons have a greater tendency to be ignited by hot deposit particles than others was also pointed out by Diggs. **"Preflame reactions** of the fuel tend to sensitize it to ignition. Under certain conditions, the effect of these preflame reactions can be minimized by tetraethyl lead."

May 3

LARGE USE OF VARIOUS RECIPROCATING ENGINES for commercial, military, personal, and business aircraft will continue for some time. This is because of fuel economy and logistics of the **fuel problem,** according to Dr. Arthur Nutt, vice-president in charge of engineering, Lycoming Division, Avco Corp.

Dr. Nutt also said that until a definite criterion is established for the comparison of reciprocating, ducted fan, and shaft turbine engines, **distorted results** will ensue.

SAE National Meetings . . .

1954

June 6-11
Summer Meeting
The Ambassador,
Atlantic City, N. J.

August 16-18
National West Coast Meeting
Hotel Statler, Los Angeles, Calif.

September 13-16
National Tractor Meeting & Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 5-9
National Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 18-20
National Transportation Meeting and Truck and Bus Engineering Display
The Sheraton-Plaza
Boston, Mass.

October 26-28
National Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 4-5
National Fuels, and Lubricants Meeting
The Mayo, Tulsa, Okla.

1955

March 1-3
Golden Anniversary
Passenger Car, Body and Materials Meeting
The Sheraton-Cadillac Hotel,
Detroit, Michigan

March 14-15
Golden Anniversary
Production Meeting and Forum
Netherland Plaza, Cincinnati, Ohio

April 18-21
Golden Anniversary Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Statler and McAlpin Hotel, New York, N. Y.

January 10-14
Golden Anniversary
Annual Meeting and Engineering Display
The Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

June 12-17
Golden Anniversary
Summer Meeting
Chalfonte-Haddon Hall,
Atlantic City, N. J.

New Forum Sponsor

George F. Chapline, vice-president and general manager, Fairchild Engine Division, Fairchild Engine & Airplane Corp., has accepted the invitation to serve as Sponsor of the 1955 SAE Aeronautic Production Forum. The Forum will be held on April 18, 1955, in New York City.

You'll . . .

. . . be interested to know that . . .

W. W. MOSS and G. C. PRILL have been named to the Air Transport Activity Committee. Moss is a captain with Pan American World Airways, Inc., at New York International Airport, L. I., N. Y.; Prill is technical director of Aircoach Transport Association, Inc., Washington, D. C. . . . J. H. FAMME, assistant chief engineer with Consolidated Vultee Aircraft Corp., San Diego, Calif., has been named to the Aircraft Activity Committee . . . and A. GIL SPEAR, JR., chief stylist, Special Projects Department, Ford Motor Co., has been appointed to the Body Activity Commitee.

EDWARD C. WELLS, vice-president, engineering, Boeing Airplane Co., has been appointed SAE representative on the Daniel Guggenheim Medal Board of Award for the three-year term beginning Oct. 1, 1954. He succeeds R. P. LANSING, whose term expires on Sept. 30, 1954. . . . Other SAE representatives now serving on the Board are W. W. DAVIES and R. P. KROON, whose terms will expire Sept. 30, 1954 and 1956, respectively.

SAE Student News

Yale University

Yale's SAE Club has been reactivated. Late in the spring of '53 a meeting was arranged at which ideas were expressed regarding this year. The result was that thirty-nine members have had a full program and the Club is planning to petition for branch status next fall. A charter committee will work during the summer.

For a field trip, the students visited the Chevrolet and Fischer Body assembly plants in Tarrytown, N. Y. last Fall. At the November technical session, John Elpi held a round-table discussion on the many facets of fleet operation. Elpi is service manager of the Cooley Chevrolet Co. and president of the Chevrolet Service Managers Council.

Opportunities for young engineers in the automotive field and allied industries was presented in December by the director of engineering research at Ethyl Corp.

Most important for the students was the March meeting. The Branch was host to the Southern New England Section of SAE. A dinner-meeting was held for the occasion and Speaker L. J. Crooks, Consumers Union Consultant, presented "The 1954 Automobile from the Consumers' Viewpoint." "The Big Race," a film, was shown, too.

A field trip to Sikorsky Aircraft in Bridgeport was made in April, and the last meeting of the year was a dinner meeting at which next year's officers were elected.

University of Wisconsin

On April 7 the Branch heard J. W. Collins, sales engineer of the Aluminum Co. of America, speak on aluminum welding. His talk was accompanied by two color films.

Next year's officers have been elected and are: Chairman Camden Nelson, Vice Chairman Charles Gunderson, Recording Secretary Roger Carlson. Treasurer George Steinl, Corresponding Secretary Eugene Worscheck, and Polygon Board Representative Lee Reese.

Donald Ermer has been elected Senior Polygon Board representative to replace David Vinton. Vinton has been elected president of the board, and Anthony DeMatthew is Junior Polygon Board representative. This board is a body whose members represent the various engineering societies. Its function is to coordinate and direct large scale activities.

L. Morgan Porter, chairman of the Southern New England Section, is shown addressing Yale's SAE Club. Section members were guests of the students last March 3.

Aeronautical University

A gleaming gold-plated trophy was awarded to Malie Leone because of his victory in Chicago Section's SAE Student Competition, April 8. Held in the Illinois Institute of Technology, the competition was between a student from Northwestern University, one from Illinois Institute, and Leone. Leone also has a year's free membership in SAE which he won previously at Aeronautical University's competition.

His paper, "An Application of Plastic to Aircraft," is primarily a discussion of "Lockfoam." This is a plastic derivative which is poured into a structural cavity. It reduces the structure's chance of failure due to vibration. Lockfoam is in a fluid state but changes almost instantly when poured to a solid foam-like state.

Incidentally, Aero U. was doubly represented at the Chicago Section competition since Chairman Robert D. Samuelson presided over the entire program.

At the April 19 meeting, members saw "A Prior Calim," a Moody Bible Institute of Science film. A sound film and in technicolor, its theme is that no matter what man has invented, nature had it first—and with a higher degree of efficiency. Because of nature's more efficient counterpart of our inventions, scientists are looking more and more to nature in their search for better aids to mankind.

University of Oklahoma

Thirty-five completely restored autos dating back to 1900 were seen by Branch members at the April meeting. The cars are all in running condition and equipped with 1954 license tags.

William Stewart, who owns the auto museum, told stories about how the cars were obtained and something about the original owners. Stewart also pointed out cars that were used in filming the movie, "Tulsa."

Of particular interest were a 1923 all-aluminum bodied Marmon, a '29 Rolls Royce, a 1917 Olds, a T-Head Mercer Raceabout, and a 1937 Mercedes.

On April 21, the students elected next year's officers. They are: Lawrence H. Sluder, president; Robert A. Fry, vice-president; Robert H. Paapanen, secretary-treasurer.

A film, "The Cummins Diesel Racecar" was shown, and each member received a 260 page handbook.

SAE Section Meetings

Canadian—June 24

Westmount Golf Club. Dinner 6:30 p.m. Annual Golf Tournament.

Chicago—June 25

Tam O'Shanter Country Club. Annual Social Ladies Night. Dinner, entertainment, dancing.

Cleveland—June 18

Elyria Country Club. Just south of Elyria, Ohio on Route 20.

The following Sections have advised us that they will not hold any meetings during the summer months:

Buffalo	Philadelphia
Detroit	St. Louis
Indiana	Salt Lake

Why Helicopters Suffer Fatigue Failure

Based on paper by

HARRY TOBEY

Piasecki Helicopter Corp.

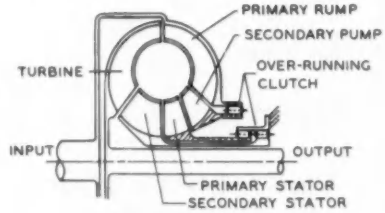
IF a helicopter is unavailable for its mission, or forced to abort its mission, because of fatigue failure of some secondary structure, bracketry, or equipment, it can be as disastrous as if due to the destructive failure of some element of its primary structure. Service reports indicate clearly that there is much greater incidence in this first category than in the second.

There are many different reasons for these failures, but they can usually be assigned to an error in one of three categories—material, detail design, or unknown loading. The relative frequency of failures in each category varies for different models and different companies. However, failures due to unknown loading do form a consistently higher percentage of the total.

In evaluating these loads the designer must avoid falling into a trap similar to that which ensnared early investigators of the fatigue properties of materials. This was neglect of the large scatter and the statistical nature of the fatigue properties of materials. A similarly large scatter can be found in many fatigue load evaluations. (Paper "Secondary Fatigue Loading of Helicopters" was presented at SAE Annual Meeting, Detroit, Jan. 14, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price; 35¢ to members, 60¢ to nonmembers).

Twin Turbine Raises Dynaflow's Efficiency

Based on paper by **R. J. GORSKY** General Motors Corp.



FIVE ELEMENT DYNAFLOW

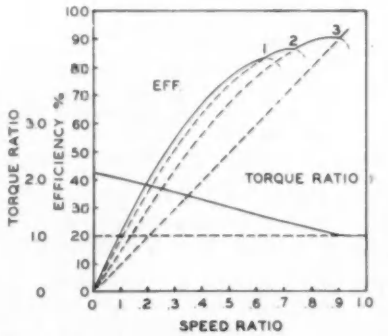
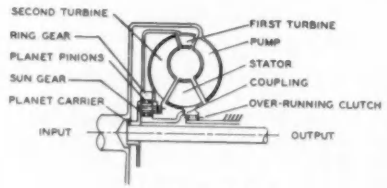


Fig. 1—This shows the original Buick Dynaflow torque converter transmission which employed a single turbine and was, in a sense, three torque converters and a fluid coupling combined in a single unit.

THE original Buick Dynaflow torque converter consisted of a primary pump, a secondary pump mounted on an overrunning clutch, a turbine, and two stators which also were mounted on overrunning clutches. It was, in a sense, three torque converters and a fluid coupling combined into a single unit. (Fig. 1). This construction resulted in four sets of curves of which the most desirable portions were utilized. The break points 1, 2, and 3 in the efficiency curve are the points at which the secondary pump stops overrunning the primary pump, the secondary stator starts to free wheel, and the primary stator starts to free wheel, respectively.

To improve car performance and converter efficiency, and to reduce engine speed for a given car speed, the twin turbine Dyanflow transmission was introduced on the Buick 1953 models. (Fig. 2).

This design uses the torque multiplying characteristics of a planetary gear set in conjunction with the torque multiplying ability of a hydrokinetic torque converter, and retains the smooth, uninterrupted power flow, characteristic of a fluid torque converter. The arrangement of this new design is unique in that all the power transferred is through the gear set and first turbine at low speeds, and gradually and smoothly diminishes as the power transferred through the second turbine increases until it does all the work at higher speeds. (Paper "Buick's Twin Turbine Dynaflow Transmission" was presented at SAE Dayton Section Meeting, Dayton, Jan. 19, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).



TWIN TURBINE DYNAFLOW

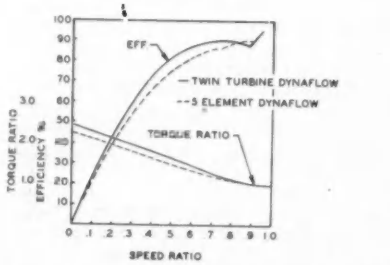


Fig. 2—Here, in contrast, is the Dynaflow transmission of 1953, employing a twin turbine. The curve shows the relative efficiency and torque ratio of the original 5-element Dynaflow and the modern twin turbine type.

Koldflo Extrusion Cuts Production Costs

Based on paper by

D. I. BROWN

Mullins Mfg. Co.

THE Koldflo process of cold extrusion can eliminate many operations required to produce a finished part. It also permits the use of designs hitherto impossible or uneconomical with conventional methods. Thus, it presents an opportunity to broaden the field of basic design as well as to reduce manufacturing costs.

Cold extrusion is not a one-shot method. Operating procedures in production vary with the part to be made. Some of the more complex parts require as many as seven operations. In some cases, two anneals are needed, particularly where the reduction of a single operation or a culmination of operations exceeds 85%. At times, final sizing operations are desirable.

Lubrication is important, but experience tells us that it is not the key to successful mass production of cylindrical shapes. The key is die design and sequence of operation, using pressures and speeds best suited in each

step. When these are properly applied, carbon steel has proven to be a decidedly plastic material, capable of great formability.

Thus far we have used 1010 aluminum killed, hot topped, shell quality steel for all commercial developments. We are not yet extruding any alloys, stainless, or non-ferrous metals. The low carbon steels are easier to handle and are capable of developing ultimate strengths of about 110,000 to 115,000 psi. We have extruded higher carbon steels successfully, but we much prefer to work 1010 or 1012. Higher carbon steels work harden faster and more anneals are often required to achieve the final shape or size. (Paper "Koldflo Extrusion Permits New Advances in Design" was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 3, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers).

Money-Saving Rules For Brake Maintenance

Based on papers by

R. H. MOORE

Conestoga Transportation Co.

and

R. A. GOEPFRICH

Bendix Aviation Corp.

THE wide spread in brake performance between passenger cars and loaded commercial vehicles can be narrowed by exercising more care in balancing the brakes of commercial vehicles. Brake balancing, together with a well-planned maintenance program, can reduce costs per mile by giving longer brake life, reducing road failures, increasing tire mileage, and by improving safety.

Estimated savings in both maintenance time and lining costs have run from 35% up, depending on the level at the start. One large bus company increased lining life 62% after installing a brake balancing program.

In such a program, all large and small factors pertaining to actuation and control must be considered. Variations in air pressure required to expand shoes, for example, is especially important when a great many stops are made at relatively low air pressures. A difference of 5 lb or more is relatively unimportant when the total brake pressure is 60 psi, but is tremendously important with brake pressures of 20 psi or less. Both front and rear brakes should be applied against the drum simultaneously. Many people disagree with this, but experience has indicated better braking with less applied pressure and much less tendency to skid.

To avoid the chance of a dragging brake due to out-of-round or eccentric drums, adjust brakes with the vehicle jacked up and check for a free wheel after the adjustment is made. But be cautious. If there is considerable looseness in the wheel bearings, and the vehicle is lowered to the ground, the clearance between the lining and drum is reduced by the amount of the looseness, and a dragging brake may result. Therefore, it is wise to check the clearance with a feeler gage, or if this is impossible, run the vehicle without a brake application and see if the drums get hot.

Complete failure of a hydraulic or vacuum system due to leak is rare. A leak in the hydraulic system is almost always manifested by a falling away of the brake pedal under pressure. A serious vacuum leak in the power portion of the system is usually indicated by a hard pedal, but minor leaks, which

Even before electricity replaced oil for automotive lighting—Tung-Sol began to acquire ability to mass produce uniform, reliable miniature lamps.
Today, there are millions of automobiles equipped with Tung-Sol Lamps and Signal Flashers and Electron Tubes for radios and automatic headlight dimmers, testimony to the importance of Tung-Sol experience—the dependability of Tung-Sol quality—and the reliability of Tung-Sol service.
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TUNG-SOL®
AUTO LAMPS
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grow to big ones, are hard to detect unless a leakage test is made every six months. It only takes a few minutes.

Too few people realize the danger of using inferior brake fluids, or their prevalence on the market. This is true despite great efforts made by the SAE Brake Fluid Committee and other agencies to educate the public. F. J. Markey, chairman of this Committee, has pointed out in a paper that there are still dozens of brands on the market with boiling points of less than 180 F. SAE specification for this characteristic is 230 F for moderate duty fluids and 300 F for heavy duty fluids. Proposed specification for an "ideal" fluid calls for the minimum boiling point to be 500 F. Considering that even moderate duty fluid is inadequate in many vehicles, and that many manufacturers are now using only heavy duty, the menace of inferior fluids becomes apparent.

The danger of using such low boiling point fluid is this: In severe braking enough heat may be generated to cause the fluid to vaporize; with this change from a liquid to a gaseous state, ability to brake is completely lost.

Boiling point is, therefore, most important, but there are other characteristics needed in a fluid which are inadequate in a sub-standard fluid. Among them are: freezing point, viscosity, lubrication, effect on rubber parts, water absorption, and anti-corrosion qualities. Inferiority of any one of these can cause improper brake functioning. (Papers "Heavy Duty Brake Maintenance and Brake Balancing Procedures"—Moore, and "Brake Maintenance Pays"—Goepfrich, were presented at SAE Annual Meeting, Detroit, Jan. 11, 1954. They are available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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● Note in Fig. 1, how the spring washer base is arched before tightening. It has strong spring tension to pull up parts tightly, yet is resilient enough to prevent stud breakage or damage to moulding. When tightened (Fig. 2) the washer base is flattened, causing spring forces A-A and B-B to be exerted inward and upward on the stud threads and downward on the assembled parts. This live spring action resists loosening under vibration.

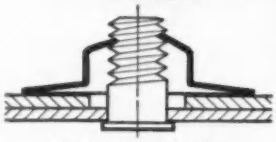

Fig. 1 Before tightening

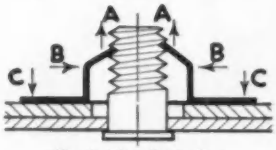

Fig. 2 After tightening

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How to Use Magnesium Castings for Long Life

Based on paper by

R. F. BREYER

Bell Aircraft Corp.

THE endurance limit cannot be used as the sole criterion for selection of materials for fatigue-susceptible parts. The slope of the S/N (stress versus number of stress cycles) curve and notch-sensitivity-life cycle relationship must be considered. This point is illustrated by the life results obtained on magnesium and aluminum castings during repeated load testing of the control system on the Bell Model 61 tandem rotor helicopter.

The castings were designed originally for and made from aluminum alloys. But the need to save weight brought consideration of changing to magnesium alloys. Magnesium castings were then made from the same patterns employed for aluminum castings, so that repeated load tests afforded a direct comparison of identical aluminum and magnesium castings under identical oscillating load conditions. It was found that very premature failures were encountered with the magnesium castings working at high stress levels, whereas satisfactory life was obtained at lower stress levels. It was found also that stress concentrations which produced no harmful effects on the aluminum castings were disastrous in the magnesium.

This observed behavior is in agreement with published data which shows that notch sensitivity makes it imperative to take care in designing castings to be made of magnesium, but that weight savings and even increased life can be obtained through use of magnesium castings by designing to minimize stress concentrations, specifying

proper surface finishes, and operating at the allowable stress levels. (Paper "Fatigue Proofing Helicopter Components" was presented at SAE Annual Meeting, Detroit, Jan. 14, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Torqmatic Converter Speeds Work, Cuts Cost

Based on paper by

J. W. CROOKS

Allison Division, General Motors Co.

THE Allison Torqmatic Converter is basically a hydraulic transmission which automatically and infinitely varies torque multiplication as high as 3.6:1, depending on load requirements. At loads equal to or less than engine torque, the converter operates automatically as a fluid coupling enabling transmission of efficient cushioned power throughout the high speed range.

Converter equipped machinery can do more work mainly because the automatic torque multiplying feature holds output horsepower closer to the maximum horsepower available throughout the entire working portion of the speed range. There is no sudden drop off of power in the working speed range as speed decreases.

Use of the converter has thus far been restricted to large and expensive equipment because of the higher first cost incident to comparatively low volume production. Its application to medium and small size industrial equipment will follow when its merits are more widely appreciated. (Paper "Operating Advantages and Usage of Allison Torqmatic Converters" was presented at SAE Western Michigan Section Meeting, Muskegon, Oct. 20, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Ford's "Oscar" Aids Seat Designing

Based on paper by

EDWIN C. PICKARD

Ford Motor Co.

"OSCAR" represents what we consider to be the correctly proportioned manikin for car and seat design work. We decided that a slightly larger than average man should be used because of the tall man's disadvantage in seating. "Oscar", therefore, is an 80 percentile man, which means that 80% of the male population has his weight and height or under. He weighs 165 lb and is 5 ft 9-½ in. tall.

We discovered that a man seated in a front seat will slouch an average of 1 in., and in the rear seat slouch an average of 2 in. This has proven to be an important factor in arriving at the proper eye level and head room. When a person stands erect the spine is concave, when seated the spine is convex. This has the effect of lowering the head in relation to the buttocks. We also discovered that the head is in a vertical position in relation to the neck and body no matter how much the person slouches in the seat. For this reason, we installed two levels in "Oscar's" head—one in his forehead and one over his left ear—which permit correctly positioning his head. Based on the proportions of the average man, we determined the proper location of his joints and center of gravity; he can be locked in any given position, or the joints can be moved

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BELOIT, WISCONSIN
BRANCH OFFICES: CHICAGO, ILLINOIS, HIGH POINT, NORTH CAROLINA, MEMPHIS, TENNESSEE, PORTLAND, OREGON

freely. The manikin is properly weighted and balanced as to arms, head, body, and legs in accordance with a chart developed by Prof. W. E. Lay at the University of Michigan. "Oscar's" back contour was developed for a seated position and not as if standing erect. Shoes are incorporated in the foot design to aid in developing foot pedal, brake and accelerator locations. A spacer is used at the belt to make up for the 1 in. difference in slump between front and back seat.

In planning a new car body we begin by outlining the over-all size which we call the package size. We do this by seating "Oscar" in the proposed body in correct position to get maximum seating comfort and head room for the particular length of chassis to be used. After the package size has been established and the Body Drafting Department has determined the floor and seat adjustor, we design a seat that will position the passenger in accordance with the package size drawings. (Paper "The Use of 'Oscar' in Seat Design" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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BORG-WARNER CORPORATION
CHICAGO 38, ILLINOIS

Six Ways to Lessen Fretting Corrosion

Based on paper by

E. M. JOHNSON

The Texas Co.

IF a lubricant becomes excluded from between bearing surfaces, fretting corrosion proceeds at an increasing rate. J. O. Almen has demonstrated that great reduction in this type of corrosion results from the use of low-viscosity fluid lubricants, and that it is desirable to submerge the bearing surfaces in the lubricant to exclude oxygen. Therefore, feedability, or ability of a lubricant to replenish itself between bearing surfaces, becomes the most important factor in reduction of fretting corrosion. This can be accomplished by using soft grease, a shear-susceptible product, or a lubricant which will permit bleeding of an oily phase.

There is no known panacea. Due to the number of factors entering the fretting corrosion problem, each individual case requires determination of the applicable variables and environment before a solution can be obtained. Some cases may dictate the redesign of portions of the equipment; others may be alleviated or completely cured by adoption of the following suggestions which are pertinent:

1. Submerge or flood bearing with lubricant of maximum feedability.
2. Relubricate bearing frequently to flush out accumulated fretting debris.
3. Modify rubbing surfaces. Vapor blasting; anodizing; baked-on Teflon; or sacrificial coatings of lead, chromium, indium, or copper may be helpful.
4. Harden one steel surface by heat-treating or metalizing.
5. Coat rubbing surfaces with rubber or rubber cement.
6. Increase amplitude of oscillation of antifriction bearings until ingress of fresh lubricant to rubbing areas is obtained. (Paper "The Effect of Lubrication on Fretting Corrosion" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Based on Discussion

E. L. Armstrong, Socony-Vacuum Oil Co., Inc.

Manufacturers of lubricants can state their side of the fretting cor-

rosion problem with a concise list of "do's" and "don'ts" better at this time than machine designers can clarify the various mechanical factors involved. We would like to see equipment designers and builders devote more attention to minimizing fretting corrosion damage from a design standpoint.

Dr. F. T. Barwell,

The action of a lubricant in facilitating the escape of debris is of obvious importance, but an equally important function is service as a barrier to slow down the access of oxygen to freshly exposed metal. Where conditions permit the use of phosphated surfaces which can be generously lubricated with oil, fretting corrosion is reduced to negligible proportions.

Gasoline Additives

Based on paper by

C. O. TONGBERG
N. V. HAKALA
L. E. MOODY
J. B. PATBERG

Esso Laboratories, Standard Oil Development Co.

A SURVEY of gasoline additives made recently by Esso Laboratories indicates, among other things, that:

- Salts of alkaline metals offer little promise as combustion catalysts. They do not effectively remove carbonaceous deposits from combustion chambers.
- Deposit modifiers studied to date do not offer sufficient advantages to offset their disadvantages.

These conclusions, drawn from both laboratory and field tests, evoked considerable comment and debate at an SAE Annual Meeting Fuels and Lubricants session on Jan. 14, 1954.

(To ensure a complete presentation of the entire story, the paper, "Gasoline Additives," **as well as two lengthy discussions of it,** is being made available from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Truck Regulation Promises to Increase

Based on paper by

DONALD E. MEYER

Student, Michigan State College

IN this paper the author presents a detailed study of legal regulations affecting commercial vehicles, classifying them as weight and dimensional limits, and safety and performance requirements. He follows this with a similarly detailed study of the effect of such regulation on vehicle design. It is his conclusion that legislation will grow as the trucking industry grows, with a solution of some problems and creation of others, and that designers and manufacturers should keep one step ahead of regulations, if possible. (Paper "Legal Regulation—Its Effect on Commercial Vehicle Design" was one of the two winners of the SAE Student Paper Contest sponsored by the SAE Mid-Michigan Section, May 1, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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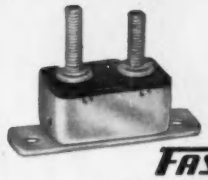

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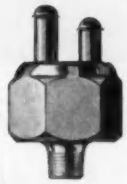

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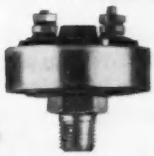

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Experts Disagree On Fretting Corrosion

Based on paper by

F. W. FINK
Battelle Memorial Institute

ALTHOUGH there is very little agreement as to the effect of many of the variables in fretting corrosion, this much has been brought to light by research: If the surfaces are to be protected by a suitable lubricant, a rough surface is preferred because the lubricant will then have more ready access to the centers where rubbing contact is taking place. If the conditions are such that the gross slip is small, increasing the load may prevent slip altogether. Closeness of fit must be considered along with other factors such as lubrication. If the fit can be made so tight that there is no motion at all, it follows that there will be no fretting.

One investigator has shown that hardened tool steel on hardened tool steel suffered less fretting corrosion than ordinary steel on steel under similar conditions. However, all the metal combinations he studied suffered fretting corrosion. Tool steel on stainless was a particularly bad combination.

Surface treatments such as shot or vapor blasting have increased the life of parts subjected to fretting, but it is not clear whether increased hardness or some other factor is responsible. (Paper "Review of Fretting Corrosion Theory" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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Full Adjustability Is Goal for Seating

Based on paper by

F. C. MATTHAEI, JR.
American Metal Products Co.

Complete paper will appear in 1954 SAE Transactions

OSCAR the seating dummy "represents" the American male, but more than 60% of us vary sufficiently from Oscar's dimensions to warrant some adjustability in seating. Furthermore, each of us has likes and dislikes which influence the seating problem.

Having built a track adjustable manually for three different conditions, we tried it out with a number of people and this is what we found:

1. Personal likes and dislikes have greater bearing on seating position than physical dimensions.

2. Seating angle afforded by present production automobile seats and fore-and-aft seat tracks represent the average angle chosen as the most comfortable—approximately 15 deg (angle of seat cushion to a horizontal line). However, the range of angle selected as most comfortable varied from 11 to 17 deg.

3. Approximately 75% of the people surveyed positioned the seat higher than afforded by the present fore-and-aft track.

With a universal positioning seat track, permitting the individual to adjust the seat for greatest comfort, each person becomes his or her own seating engineer. The driver will then be able

to get maximum visibility, suffer less fatigue, and be a better and safer driver for it.

The track of the future will have several adjustments—fore-and-aft, up and down, and angularly. The adjustments will be made manually on low-priced cars, and by power in the luxury field. (Paper "The Universal Positioning Seat Track" was presented at SAE Annual Meeting, Detroit, Jan. 11, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Adhesives Now Bond Airframe Structures

Based on paper by

GEORGE E. HOLBACK

and

JAMES L. BURRIDGE

The Glenn L. Martin Co.

Complete paper will appear in 1954 SAE Transactions

IN Air Force and Navy projects being carried out at the Martin plant, we are using adhesives to join metal skins to low density cores, thus forming sandwich type structures, and to replace rivets and bolts in attaching one metal part to another. Both of these adhesive applications in the construction of a single part have led to major weight savings and to lower manufacturing time and cost.

The low density core is Honeycomb—a material fabricated by joining corrugated aluminum foil with adhesives to form hexagonal cells. The same adhesive is used throughout. Known as FM-47, it is a development of an earlier vinyl-phenolic thermosetting adhesive called FM-45 and Plycozite. It is available both in liquid form and as a prepared film—from which part of the solvents have already been removed. The film derives strength for easy handling from its carrier of open weave Fibreglass cloth.

The Gorgon IV, a pilotless aircraft, employed the first flight surface of sandwich construction. Approximately 80 wings were made. No metal-to-metal bonding was involved. The Martin 2-0-2 and 4-0-4 used structural Honeycomb floors consisting of flat sandwich panels. Then much development work was done on sandwich panels for cargo floors.

Next, came the ISSM—experimental version of the Matador—which used sandwich type surfaces throughout, as well as flat panels for tank floors and some bulkheads. A production version of the Gorgon IV, known as the KDM-1, followed. This embodied the first major use of metal-to-metal bonding. The right and left wing panels were joined at the center line by gluing the wing coverskins to an aluminum casting.

These applications, all involving production in some volume, paved the way for the B-61A. After the B-61A there came the developmental use of Honeycomb bonded blankets as compression covers for the tail of the P5M-1 Martin flying boat. (Paper "A Production Application of Structural Adhesive Bonding" was presented at SAE Annual Meeting, Detroit, Jan. 14, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

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One Basic Block Serves for 66 Engines

Based on paper by

WILLIAM EDDIE

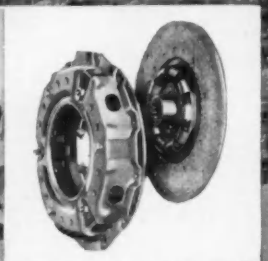
Chrysler Corp. of Canada, Ltd.

TO produce cars and trucks in Canada, at the lower prevailing production rate, requires great ingenuity to process all parts to get maximum production with minimum cost.

By way of example, in the United States we have four basic 6-cylinder engines that are machined and assembled, each in a separate plant, to power Plymouth, Dodge, DeSoto and Chrysler cars. In Canada we have one basic cylinder block from which are obtained 66 different engines to power the same line of cars plus Dodge and Fargo trucks.

It was decided originally to use one basic cylinder bore (3-⅜ in.) with the one block. Then only the stroke need be varied to produce different horsepower ratings. Accordingly, different crankshafts were set up to allow production of the different engines. Then it was found that oil hole angles varied in the different cranks, requiring either additional drilling machines or drill units with adjustable heads. However, laying out the various cranks revealed that a compromise could be made by choosing a new angle, and all cranks now have this same oil hole. Certain other operations on these cranks are the same and only in certain instances, such as turning throws or in grinding, are additional machines or other pieces of equipment required. (Talk "Engineering Ingenuity" was presented at SAE Toronto Production Forum, Oct. 29, 1953. It is available together with reports of the seven other panels at this Forum as SP-305. Price: $1.50 to members, $3.00 to nonmembers.)

HOW TO GET THE RIGHT CLUTCH



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How To Test 2-Stroke Scavenging Efficiency

Based on paper by

C. F. TAYLOR
AND
A. R. ROGOWSKI

Massachusetts Institute of Technology

Complete paper will appear in 1954 SAE Transactions

THE ability of the two-stroke engine to produce power depends upon the amount of fresh air which can be trapped in the cylinders per unit time. Therefore, one of the principal objectives of the designer is to learn how to trap reasonable quantities of fresh air, without the expenditure of undesirable amounts of scavenging-blower power.

Granting that scavenging is important, the designer not only needs to have an ideal of scavenging excellence at which to aim, but to be able to determine without too much difficulty how closely his engine approaches this ideal. To this end, the authors of this paper offer a definition of the scavenging ideal and suggest methods for measuring scavenging efficiency against this ideal. (Paper, "Scavenging the Two-Stroke Engine" was presented at SAE National Diesel Engine Meeting, Chicago, Nov. 3, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Records Are Backbone Of Fleet Operations

Based on talk by

LA VERNE MORGAN

Edward R. Bacon Co.

CERTAINLY no one would consider depositing money in a checking account and not keeping a record of his deposits and withdrawals. This is the

exact effect of buying a piece of equipment and not keeping a performance or maintenance record.

Equipment is purchased to perform a service at a profit to the purchaser. No one would consider trying to run a business without keeping enough records to show the difference between the cost of operation and his revenue.

Many transportation companies are operating without records to show exactly how they are spending 25% or more of their revenue dollar. This does not necessarily represent an efficient figure; rather, it is approximately the average figure determined by the findings of the Interstate Commerce Commission. (If anyone thinks this 25% figure is excessive, he need only to refer to the I. C. C. reports).

This 25% of the company's revenue is being spent for something which is glibly called "maintenance." Just exactly what is included in this maintenance cost? The money is generally spent for the following items:

1. Maintenance supervision.
2. Maintenance facilities.
3. Time card labor.
4. Parts and material.
5. Outside repairs.

Dividing maintenance costs into these five groups will show where most of the money is being spent; but, to establish control, the direct maintenance cost must be examined more closely.

Why examine maintenance cost items more closely? Unless the company's operation is unusual, the maintenance department has grown without any plan. Equipment was purchased and because of the convenience, the decision was made to hire a mechanic to care for it. Equipment must be available for performing its primary job at all times. No one was interested in exactly how the equipment was maintained as long as profits were good.

Some times the maintenance costs were given the 'shot gun' treatment. "They are too high, cut 'em." Just where or why they were too high or how they were cut wasn't too important. To cut cost, the truck with an engine knock was sent back out on the road. A hot rear end was released to run for another month. Next month the bill for maintenance would be lower, so management turned to other 'hot spots'; but soon the maintenance costs bounced back higher than before with more down-time and more expensive repairs.

Unfortunately, it is difficult to sell a maintenance program to management until after a serious accident has occurred or an expensive and untimely failure has been experienced. One such failure will pay for several years of maintenance paper work.

The starting point of an economically maintained fleet is a well supervised planned maintenance program. No one would think of starting a new business venture without investigating to find exactly what is required to operate the business, yet most operators

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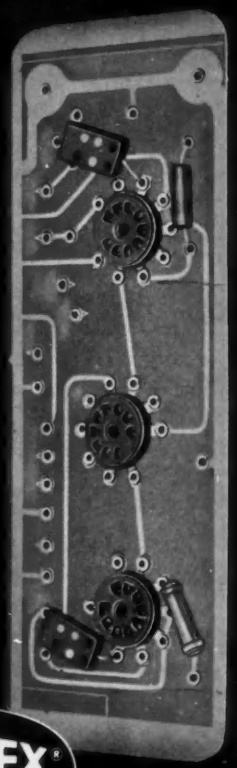

MYCALEX printed circuit tube sockets effectively eliminate broken or loose connections that ordinarily result from tube insertion and removal, shock and vibration. An exclusive MYCALEX contact design permits a positive mechanical attachment in conjunction with a soldered connection. The mechanical attachment safeguards against stress at all times, insures the permanence of the soldered connection between printed circuit and socket contact. Troublesome intermittent contacts, costly repairs are thus eliminated.

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of equipment hire mechanics to maintan equipment when the operator has only a vague idea of what he expects the mechanic to do.

A well planned maintenance program should consist of the following:

1. A schedule of all routine checks from daily inspections to major rebuild.
2. A log of the work performed on each vehicle.
3. A record of emergency repairs.
4. A tire failure analysis.
5. A cost accounting report which will allow comparing the cost of individual vehicles with the fleet average.
6. A summary sheet showing the total cost of each item of maintenance.

A properly established maintenance program enables the operator to obtain the economic service which the manufacturer has designed into it. Such a program will enable the operator to substantiate any claims of faulty equipment and parts, thus enabling the dealer to quickly and amicably settle any claims against the manufacturer.

How can a maintenance cost control system be obtained? There are no 'tailor made' systems available. Each organization has its own accounting system. To be economical, the maintenance cost system should fit the organization accounting system.

Establishing a good maintenance system will require continuous supervision. There is no easy system. The shop superintendent and organization accounting staff must be thoroughly sold on the benefits of the final system or it will never work. There are several systems in operation. The systems look logical enough on paper, but the actual supervision to keep the system in operation is an endless task.

Since the severity of service determines the proper inspection period, it is usually found economical to use different inspection periods for like vehicles in the same fleet which habitually perform different tasks. Everyone realizes that it is as expensive to rebuild equipment too soon as it is to allow the equipment to break down. If the schedule is too close, the mechanic will automatically skip the check which can also result in breakdown.

Therefore, in closing, I would like to define my idea of a maintenance system. A good maintenance cost control system is one which will establish the most economical point at which parts or assemblies are to be adjusted, rebuilt, or replaced and still provide the operator with a mechanically safe piece of equipment. (Talk "Equipment Maintenance in Small Fleets," was presented at SAE Southern California Section, Los Angeles, March 18,

1954. This digest is an excerpt of the report by Field Editor W. E. Achor.)

Charles Sands,

Safety Inspector, Bureau of Motor Carries Interstate Commerce Commission, Los Angeles, Calif.

The purpose of the government agency is to make observations and to provide help to the industry. I have compiled a list of 16 observations concerning preventative maintenance systems for motor truck and bus operation. It is interesting to note that 14 of these 16 observations were covered by the paper. It shows that our observations correlate with those of Mr. Morgan.

My list of 16 observations are as follows:

1. Motor equipment requires service **only** on a mileage basis (or motor miles) and severity of use.

2. Mileage is a constant and the same applies to all types of carriers.

3. Severity differs with most every carrier and with different operations of the same carrier.

4. Most carriers are basically businessmen, former drivers, or solicitors. Many are mechanically minded, but very few are good mechanics.

5. Many shop superintendents are foremen who came up from the ranks of mechanics.

6. Mechanics as a rule have never had training in economics or organizational work. That was not their vocational choice and they should not be expected to organize this phase of the work.

7. It is possible to remember every detail of a motor vehicle but for practical and consistent practice it does not work out. A guide is necessary.

8. A job done is no better than the skill and attitude of the man who does the job.

9. A mechanic's mind must be free of uncertainty so that he may concentrate on the job at hand and take interest in it.

10. No unnecessary work should be performed.

11. Definite work must be laid out for each man to do, as confusion and waste of time invariably result if this is not arranged.

12. Indefinite purpose, even for minor things, causes an indifferent attitude.

13. A shop foreman must be free enough to have time to study all repair details of new equipment and its auxiliary units.

14. The shop foreman must be able at any time during the day to appraise his shop load, quickly.

15. All sound business principles require a definite budget system relating

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to individual departments of that business. The maintenance department is no exception, but it must be governed on a mileage basis rather than percentage of revenue. (Reason: Item 1). Mechanical things have no relation to rates and tariffs but the reverse is true coupled with mileage.

16. Many systems have been set up and tried half heartedly because of lack of faith in its operation and lack of someone to take care of it.

Wallace Linville, Petroleum Education Institute.

Maintenance systems are not required with five or six pieces of equipment since the mechanics, drivers, and operators can be intimate with each truck the same as an individual is with his car. It's like the student in school who will learn more if he is given special attention.

When the operation is expanded to 35 or 40 pieces of equipment, this intimacy is no longer possible because a man can't remember what has been done to each truck. Then a system must be used to supplement the intimacy.

John Clark

Superintendent of Maintenance and Purchasing Arrowhead Freight Lines and Asbury Transportation Systems

I wish to caution you all about one outfit that had a very elaborate maintenance record system and a large staff of people to keep up with the accounting. The only trouble was, they went out of business. It is possible to carry the system so far that its expense outweighs its economy.

Improving Fatigue Life of 12% Cr Steels

Based on paper by

W. L. BADGER

General Electric Co.

Complete paper will appear in 1954 SAE Transactions

AS jet engines develop and efforts are made to reduce weight, material requirements become more severe. Temperature rise necessitates the use of stronger alloys and different heat-treatments. To determine the effect of hardness (tempering temperature) and alloy content on the stress corrosion resistance of several proposed alloys, tests were run using a corroding solution of 1-1 $HCl + 1\%$ SeO_2.

In addition to Type 403 stainless, several 12% chromium alloys were tested. The data obtained show advantages for the alloy-modified 12%

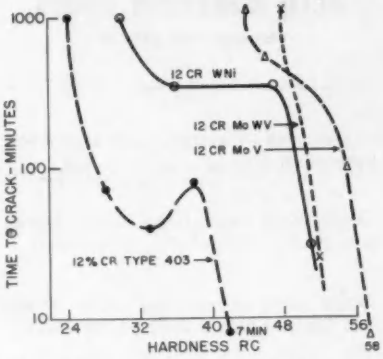

Fig. 1—Showing the time required to crack alloy modified 12% Cr steels in a corroding solution of 1-1 HCl + 1% SeO_2 at 125,000 psi.

Cr steels in that the time to failure at a given hardness and stress is much greater. Additional data are needed before definite effects can be determined. There is the further question as to the correlation of this test in 1-1 HCl + 1% SeO_2 with actual operational environments.

The life in minutes at several stress levels was tabulated for each material and hardness level and is plotted in Fig. 1. In this plot it is apparent that the modified alloys show a definite superiority over the straight 12% Cr Type 403 steels for equivalent hardness in a stress corrosion test such as was conducted. (Paper "Stress Corrosion of 12% Cr Stainless Steel" was presented at SAE Annual Meeting, Detroit, Jan. 12, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Based on Discussion

John Preston, Wright Aeronautical Div.

We are conducting stress corrosion tests of Type 403 steel in a 20% salt spray atmosphere which approximates service conditions better than an acid environment. This type of test has the advantage of long exposure periods in comparison with the short periods for specimens submerged in acid.

A significant difference between acid and salt spray tests is that failures can occur at much lower stresses in the latter. It is felt that Type 403 steel will crack due to stress corrosion in a salt spray environment at stresses below 30,000 psi, provided the material has been tempered at 1000 F. But the fracture times would be very long. Therefore, it is believed that a log-log relationship, similar to a stress-rupture curve, is an improved form for representing stress corrosion data obtained from specimens exposed in a salt spray atmosphere.

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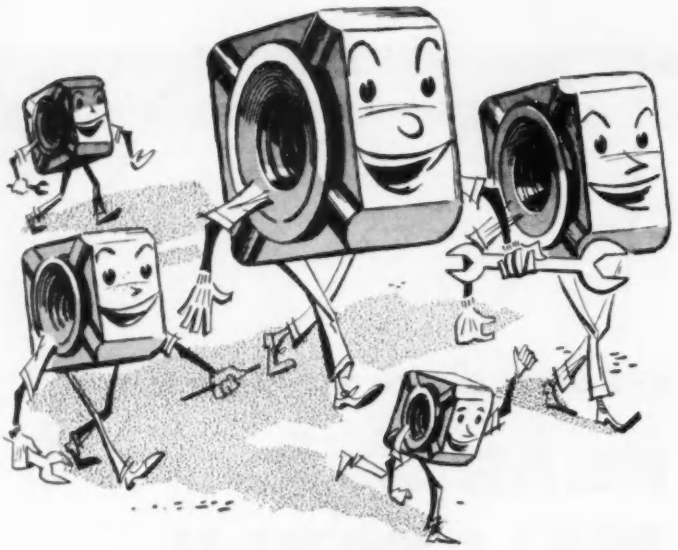

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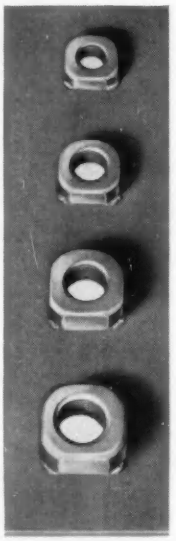

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Aero Materials Specs

continued from page 81

- AMS 2646—Contrast Dye Penetrant Inspection
- AMS 4018—Aluminum Alloy Sheet and Plate, 3.5Mg-0.25Cr (A54S-O)
- AMS 4019—Aluminum Alloy Sheet and Plate, 3.5Mg-0.25Cr (A54S-H32)
- AMS 4275A—Aluminum Alloy Castings, Permanent Mold, 6Sn-1Cu-1Ni (750-T5) Stress Relieved
- AMS 4280C—Aluminum Alloy Castings, Permanent Mold, 5Si-1.2Cu-0.5Mg (355-T71) Solution Treated and Overaged
- AMS 4281A—Aluminum Alloy Castings, Permanent Mold, 5Si-1.2Cu-0.5Mg (355-T6) Solution and Precipitation Treated
- AMS 4282C—Aluminum Alloy Castings, Permanent Mold, 4.5Cu-2.5Si (B195-T6) Solution and Precipitation Treated
- AMS 4283B—Aluminum Alloy Castings, Permanent Mold, 4.5Cu-2.5Si (B195-T4) Solution Treated
- AMS 4284B—Aluminum Alloy Castings, Permanent Mold, 7Si-0.3Mg (356-T6) Solution and Precipitation Treated
- AMS 4350E—Magnesium Alloy Extrusions, AZ61A

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- AMS 3622A—Plastic Moldings and Extrusions
- AMS 3802B—Cloth, Airplane, Cotton, Mercerized, 50 lb Breaking Strength
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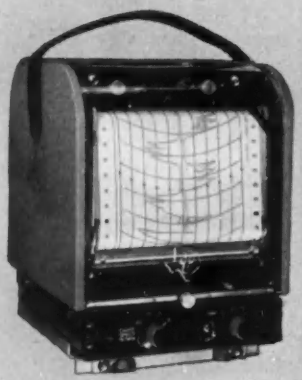

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- AMS 4674B—Nickel-Copper Alloy, Corrosion Resistant
- AMS 4730B—Nickel-Copper Alloy Wire, Corrosion Resistant
- AMS 5036C—Steel Sheet and Strip, Aluminum Coated
- AMS 5085—Steel Sheet and Strip
- AMS 5315—Ductile Iron Castings (Nodular)
- AMS 5316—Ductile Iron Castings (Nodular)
- AMS 5516D—Steel Sheet and Strip, Corrosion Resistant
- AMS 5529—Steel Sheet and Strip, Corrosion Resistant
- AMS 5536—Alloy Sheet, Corrosion and Heat Resistant
- AMS 5576A—Steel Tubing, Welded, Corrosion and Heat Resistant
- AMS 5591B—Steel Tubing, Seamless, Corrosion Resistant
- AMS 5613C—Steel, Corrosion and Moderate Heat Resistant
- AMS 5639A—Steel, Corrosion Resistant
- AMS 5642C—Steel, Corrosion and Heat Resistant
- AMS 5645G—Steel, Corrosion and Heat Resistant
- AMS 5648C—Steel, Corrosion Resistant
- AMS 5754—Alloy, Corrosion and Heat Resistant
- AMS 6323C—Steel Tubing, Mechanical
- AMS 6328C—Steel
- AMS 6354—Steel, Sheet and Strip
- AMS 6413C—Steel Tubing, Mechanical
- AMS 6415E—Steel

Bibliography Ready On Air Conditioning

THE 1486 references Committee A-9 checked in preparation of AIR 33, Air Conditioning of Aircraft at High Altitude, have been compiled and reproduced as a separate appendix to the AIR.

Users of AIR 33 may secure the appendix at 75¢ each copy from the SAE Aeronautics Division, 29 West 39th Street, New York 18, N. Y.

The references are arranged alphabetically by author's name. The subject index embodying hundreds of headings like

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Abortion
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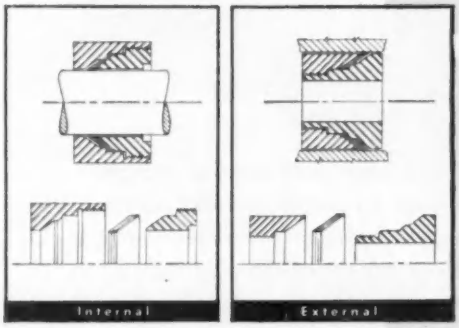

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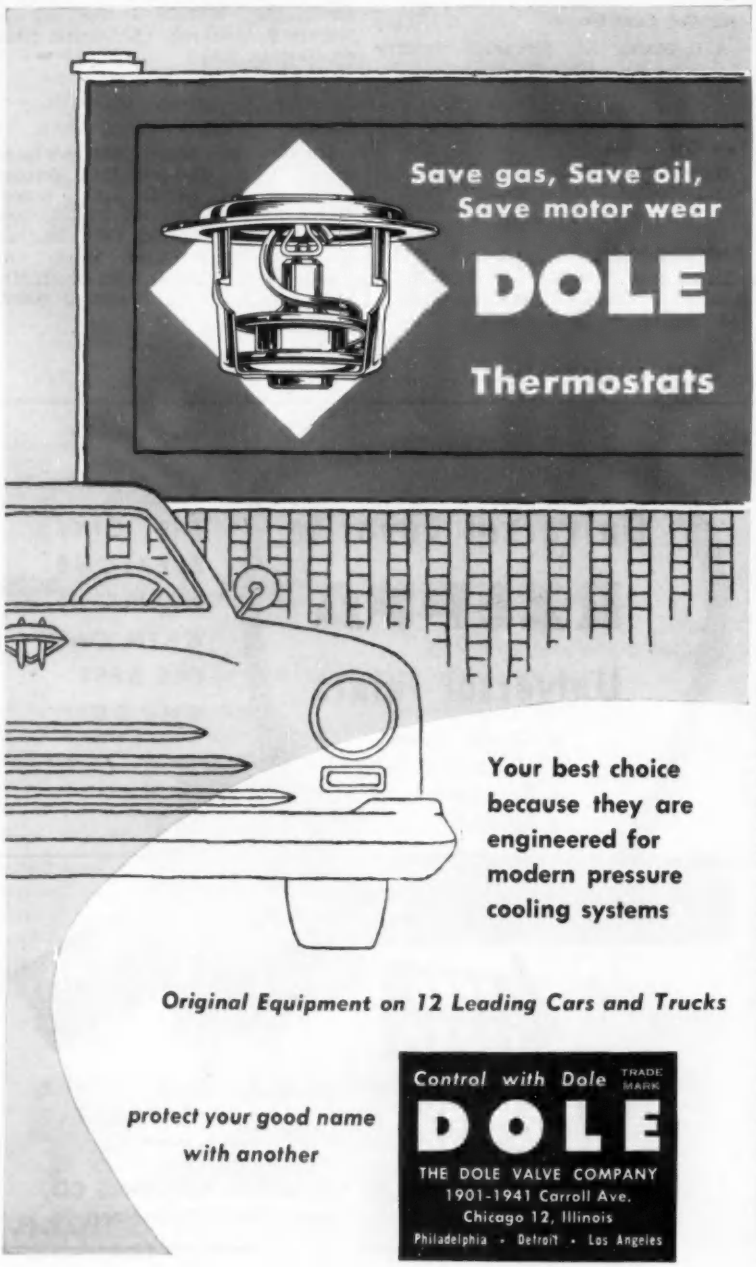
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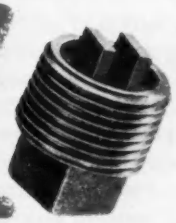

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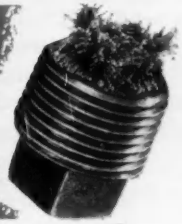

Your sample LISLE PLUGS will be sent free of charge for testing. Just state size and type of plug desired.

LISLE *Corporation*

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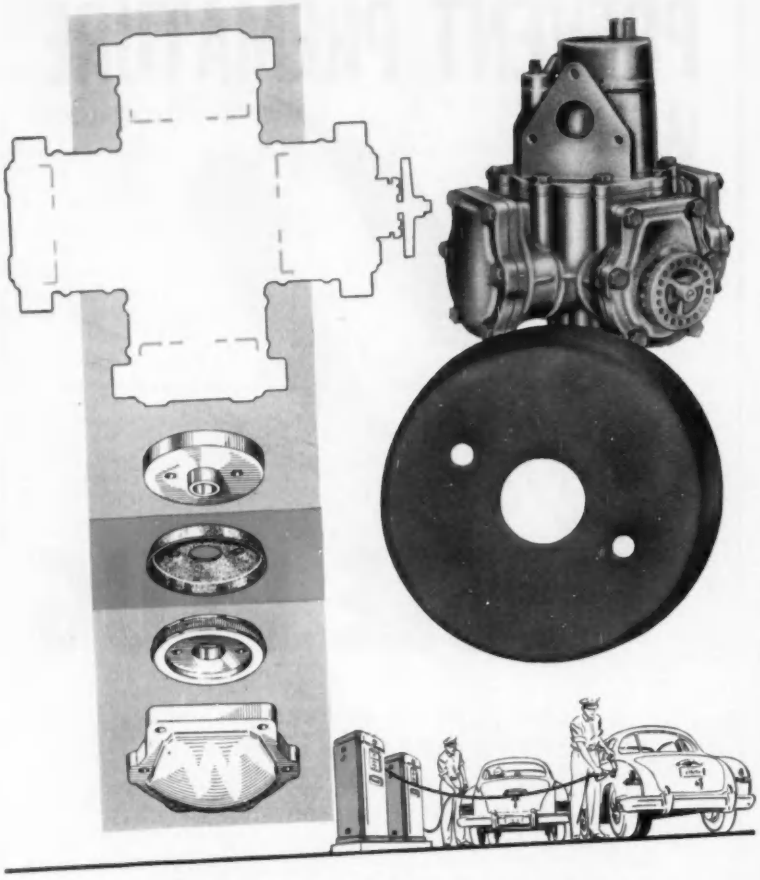

How G&K-INTERNATIONAL helps Gilbarco Pumps meter gasoline with "Split$_{db}$ drop" accuracy

The Gilbarco four-piston positive displacement meter is as nearly frictionless as any mechanism can be. You can spin it by blowing your breath into its inlet port. Yet the four pistons operate in positive leak-proof contact with the cylinder walls.

The problem is solved with four leather cup packings, coated inside to prevent the penetration of the gasoline. The cups must not vary in any dimension more than .0025 inch – a real achievement when working with leather.

Meeting *required accuracy* and *scheduled deliveries* are two *"musts"* at G&K-INTERNATIONAL. That's why you, like Gilbert & Barker Manufacturing Company, can depend upon this source for your packings in modern leather Cups, Flanges, U's, V's and Oil Seals; and in standard or special synthetic rubber packings of all types, including O-Rings.

Write for G&K-INTERNATIONAL Catalog and Manual 201-A. 60 pages of up-to-date data including latest JIC and officially recommended sizes for all types of packings.

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G&K- INTERNATIONAL *Packings*

GRATON AND KNIGHT

LEATHER — SYNTHETIC RUBBER

GRATON & KNIGHT COMPANY, Worcester, Massachusetts
INTERNATIONAL PACKINGS CORPORATION, Bristol, N. H.

P-3

Applications Received

continued

San Diego Section

George Howard Schwab, Jr., Curtis M. Smith, Robert F. Wimble.

Southern California Section

Albert B. Bishop, Howell E. Bomar, John H. Boner, Daniel W. Burns, Jr., John Kulachkosky, Thomas W. Redfield, John Louis Reynolds, William M. Rucker, William Estol Rush, Angus McNeill Saunders, Robert Smits.

Southern New England

Manfred Eugene Becker, Libero D. Ferrante, Lloyd I. Krause, Robert Raufeisen, Seymour Roth.

Texas Section

Weldon Baker, Fred N. Dickerman, Daniel G. Gilmore, D. L. Hearn, Andrew G. Lontai, Harry I. Spiegel, Paul R. Welsh, Herbert Zinberg.

Twin City Section

Carl D. Johnson, James Lovaas.

Virginia Section

Forest C. Anderson, Joseph P. Crenshaw, Walter F. Harris, Calvin W. Kersey.

Washington Section

Charles Edward Septfonds, Jr.

Western Michigan Section

Hugh Kratz, Lloyd Masser, Donald H. Ostby.

Outside of Section Territory

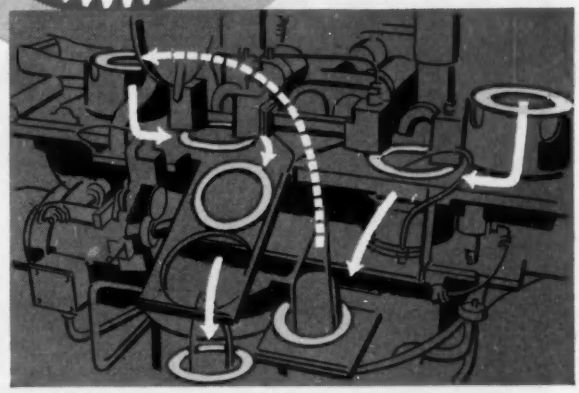
William Hobart Austry, Philip R. Bunnelle, Gordon Ness Carlson, Eugene Carpenter Coan, Frederic M. Curwin, Joel Ferrell, Jr., Donald J. Flaherty, James K. Jensen, Irvin W. Lee, Robert H. Meier, George H. Michael, Hans W. Sack, John Roy Smith, Jr., Laurence Elder Snodgrass, Wagn Trautner, Harlan W. Van Gerpen, Wesley John Wankel.

Foreign

Gustav Goldbeck, Germany; Francis Stanley Tennyson Hallam, Australia; E. M. Lemper, West Africa; James McAvoy, Scotland; Alexandre Jacques Mura, France; Chalikonda Venkateswara Rao, India; Ivan Karl Stolzenberg, Australia; Robert G. Yeamans, Italy.

moraine engineering

...planning that pays off



Better products at lower cost are usually the result of improved design *plus* improved processing. Take, for example, the clutch plates Moraine makes for automatic transmissions used in automotive vehicles. In the beginning each plate required many separate individual operations. Now these plates are fed into a specially designed automatic machine and completely processed with a great saving in labor costs. This specific example of the "forward thinking" at Moraine benefits both you *and* your customer.

From the truck and bus fields came a desperate request for a tougher bearing to withstand the many requirements of heavy-duty engines. Moraine came up with the answer in the Moraine-400, the *toughest automotive engine bearing ever made!*

Some cars and trucks with power brakes require a safety feature that would maintain reserve vacuum power for braking. Moraine provides that reserve power—an electrically driven booster pump that maintains an adequate vacuum reserve.

Moraine friction materials, able to withstand great heat and friction, are widely used in Powerglide, Hydra-Matic and Dynaflow automatic transmissions. Their use has spread to other applications . . . from military vehicles to home appliances.

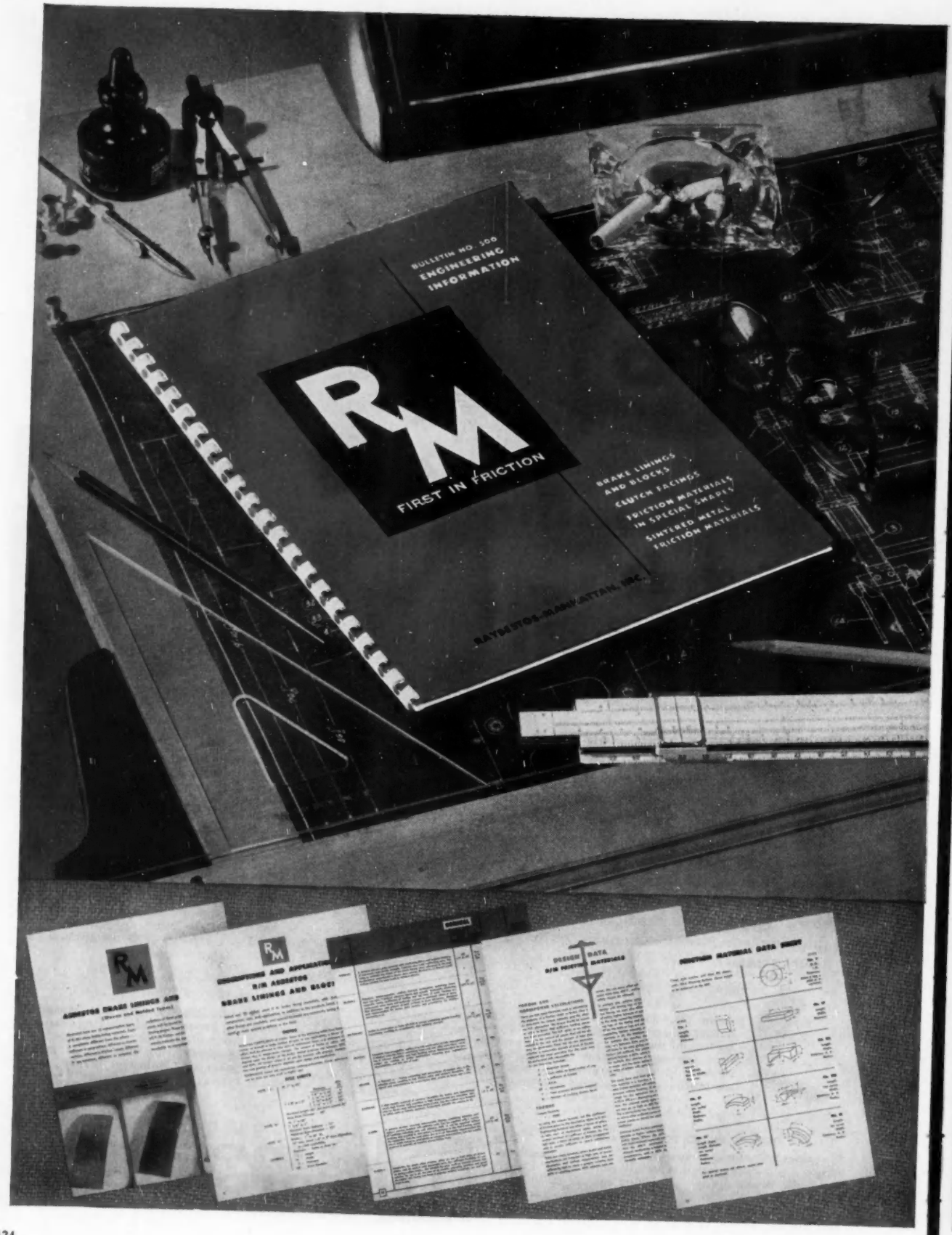
Manufacturers are learning that Moraine, through its broad metal-working experience and constructive attitude, has provided a solid foundation for the use of metal powder parts in industry. Every day, Moraine proves "It *can* be done!"

THESE PRODUCTS, TOO, ARE MORAINE

Moraine-100 engine bearings . . . Durex gasoline filters . . . Porex porous metal parts . . . Delco hydraulic brake fluids . . . Delco master cylinders, brake cylinders, and parts . . . Moraine vacuum pumps . . . Moraine conventional engine bearings and electric motor bearings.

moraine products

DIVISION OF GENERAL MOTORS CORPORATION, DAYTON, OHIO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AND BLOCKS
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FRICTION MATERIALS
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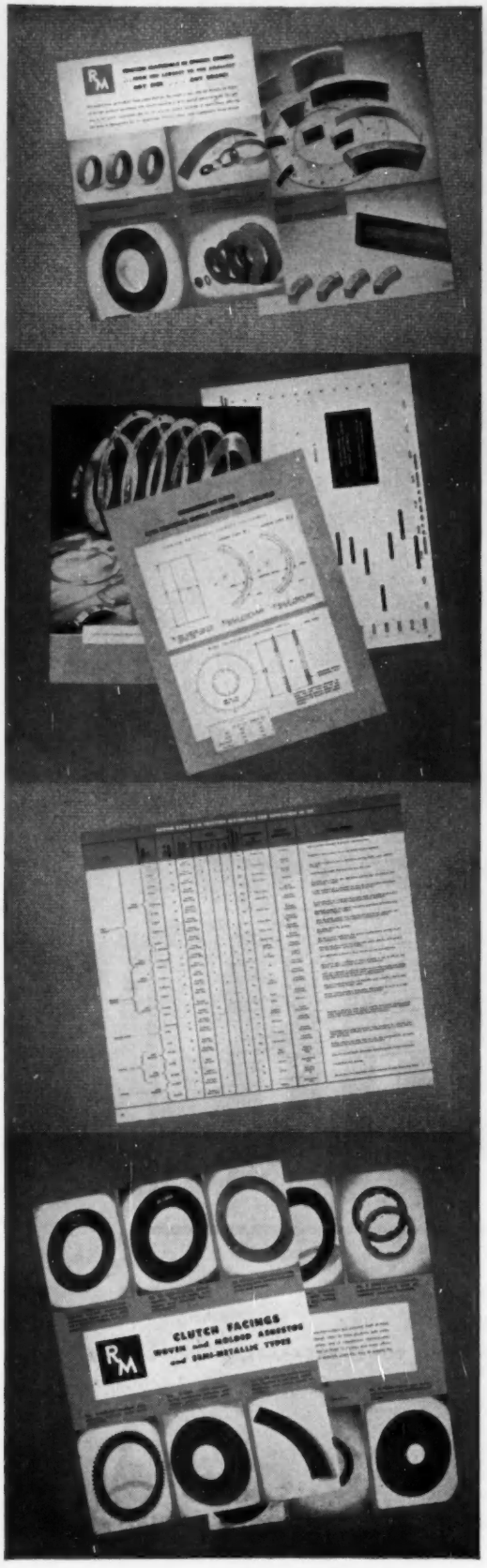

Just off the press!

R/M BULLETIN No. 500

44 pages of engineering data on the use of R/M friction materials

Pictured at the left are a few of the many charts, diagrams, photographs, and pages of engineering information included in R/M Bulletin No. 500. Engineers looking for practical design and engineering data on friction materials will find their answers in the 44 pages of this new and comprehensive Raybestos-Manhattan bulletin. Its contents are intended as a guide in the choice of the friction material and as an aid in the design of the friction device. An outstanding feature, to pick just one, is the selection chart (3rd photo from top), which gives complete design data for R/M friction materials operating in oil.

R/M Bulletin No. 500, plus consultation with an R/M representative, should enable you to reduce most of your friction material problems to a minimum. R/M, remember, is the world's largest maker of friction materials. It is constantly experimenting with countless combinations of woven and molded asbestos, semi-metallic materials, and sintered metal. And because it works in both the asbestos and the metal fields, its advice is always impartial.

Write for your free copy of R/M Bulletin No. 500

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The trade-mark that spells progress in friction material development

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Detroit 2 Cleveland 14 Los Angeles 58

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Rohr builds more power packages for airplanes than any other company in the world — and this picture shows the Rohr-built power packages on the wing of the big, beautiful Lockheed Super Constellation. In addition to producing power packages for the world's leading commercial and military planes, Rohr Aircraftsmen are currently making more than 25,000 different parts for all types of aircraft.

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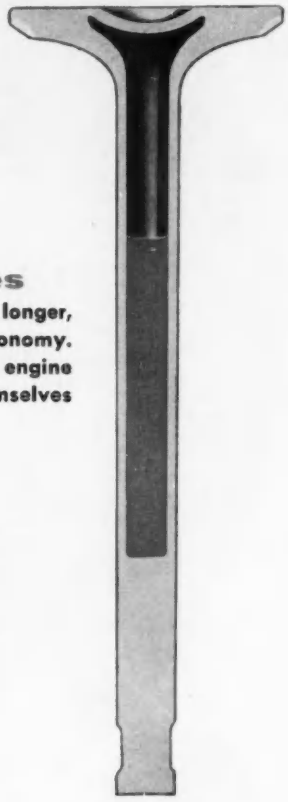
Sleeve bearings in all designs and sizes; cast bronze bushings; bimetal rolled bushings; rolled split bushings; washers, spacer tubes, precision bronze parts and bronze bars.

Eaton Offers 5 Methods of Increasing Valve Life

Eatonite-Faced Valves

Eatonite—heat resistant, corrosion resistant, wear resistant—applied to valves by a special Eaton-developed process adds materially to valve life in commercial vehicles and in heavy-duty industrial engines. Available as solid valves, hollow sodium-cooled valves, or free-valves.



Eaton Sodium Cooled Valves

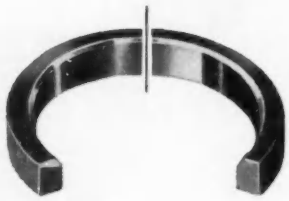
Eaton Sodium Cooled Valves run cooler, last longer, maintain a high level of engine output and economy. They ordinarily require no attention between engine overhauls; keep trucks on the job; pay for themselves many times over.

Eaton Free-Valves

Freedom to turn in either direction prevents formation of stem and uneven seat deposits; prevents sticking and scuffing; prevents valve burning and guttering; effects an appreciable increase in valve life. Eaton Free-Valves can be applied to engines of all types and sizes without costly design changes.

Eaton Hydraulic Valve Lifters

Eaton Zero-Lash Hydraulic Valve Lifters maintain zero valve clearance at all temperatures, and under all operating conditions; improve valve seating; prevent valves pounding into seats. Available in all types and in all materials, including heat-treated steel, hardenable iron, chilled-face, and puddled-face.



Eatonite Valve Seat Inserts

Valve seat inserts of Eatonite—heat resistant, corrosion resistant, wear resistant—reduce valve failure caused by prolonged operation at excessive temperatures and maintain a high level of engine output. Available for all types of engines.

EATON MANUFACTURING COMPANY

General Offices: CLEVELAND, OHIO

VALVE AND SAGINAW DIVISIONS: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

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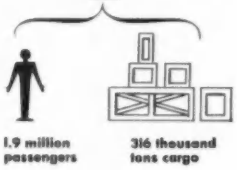


break all records for long-range

movement of troops and equipment by air

—the Douglas Liftmaster

Move everybody in Kansas to Maine —with 632 million pounds of baggage—and you equal the record airlift made by MATS in just five years.

Delivering troops and matériel to bases around the world, MATS relies heavily on its high-performance Douglas DC-6A Liftmasters. At air fields, Liftmaster's cargo hold is quickly serviced through front and rear doors, while a self-powered elevator lifts two-ton loads from truck-bed height to cabin floor level. Liftmaster's range is 2850 miles *non-stop*, at better than 300 miles per hour, with a fourteen-ton payload.

Liftmaster's performance, at low cost per ton-mile, shows Douglas Aviation leadership. *Faster and farther with a greater payload* is always the basic rule of Douglas design.

Enlist to fly with the U. S. Air Force

Depend on *DOUGLAS* **First in Aviation**

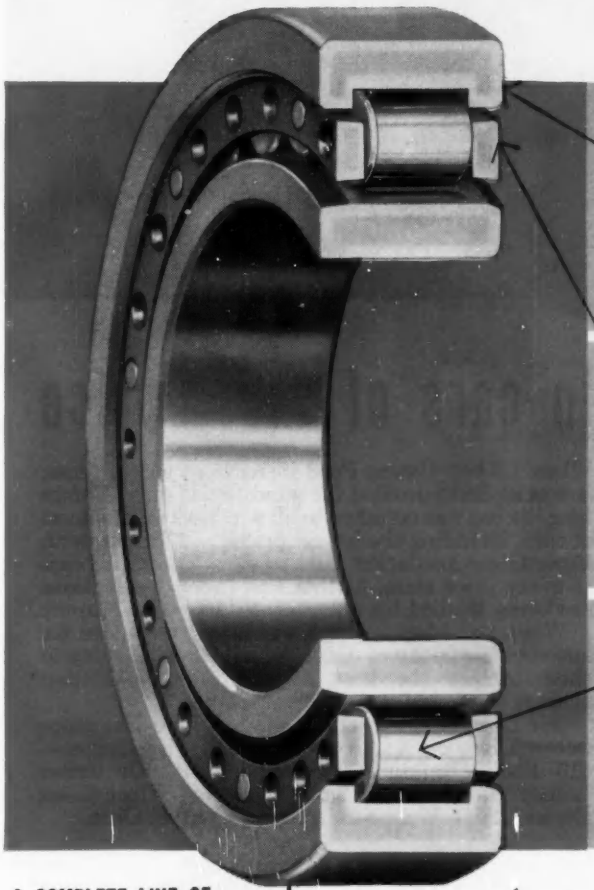
Here's why BOWER straight roller bearings can carry maximum loads—with less maintenance!

The important design features of Bower straight roller bearings shown on this page are just a few of the 'reasons why these bearings will operate efficiently and economically in your product. Consider these facts, too. Bower straight roller bearings incorporate highest quality materials and workmanship. They have proved themselves capable of standing up day in and day out under maximum loads—with little or no maintenance.

In fact, this is the reason why Bower straight roller bearings are used extensively by leading manufacturers in such fields as automotive, earthmoving, farm equipment and machine tool.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the blueprint stage.

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN



● ***TWO-LIP RACE INCREASES RIGIDITY.*** These two shoulders, made parallel, are integral with the outer race. This provides a more rigid, durable construction. Rollers are kept in proper alignment at all times.

● ***COMPOSITE STEEL CAGE DOES NOT CONTACT ROLLERS DURING NORMAL OPERATION,*** thereby allowing free movement of the rollers between the races. Projections on the inner faces of the rings engage indentations on the roller ends preventing the rollers from dropping out of position when the separable race is removed.

● ***PRECISION-BUILT ROLLERS AND RACES ARE MADE TO SUPPORT MAXIMUM RADIAL LOADS.*** Only the highest grade steel-alloy is used, and rollers and races are precision ground to give quieter, smoother operation. Running clearance is built in at the time of manufacture.

A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS FOR EVERY FIELD OF TRANSPORTATION AND INDUSTRY

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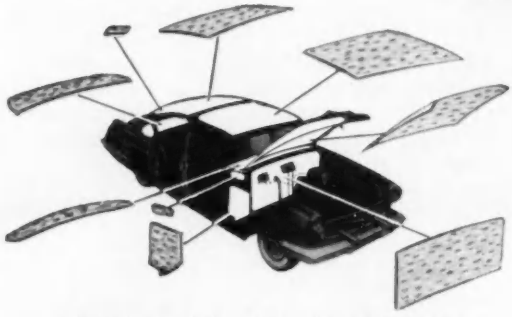

L·O·F Super·Fine Fiber·Glass insulates a car throughout against heat, cold and sound. Installed under the hood, it reduces high-frequency engine sounds, transmitted tire whine, and air stream whistle.

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When Libbey·Owens·Ford introduced safety glass, it was at first specified for windshields only. Before long, its use was common in all windows of all makes of cars, including the lowest priced . . . Today, with Fiber·Glass insulation used to some extent by cars in every price class, further and fuller applications are being studied by all automobile manufacturers.

When the adoption of Fiber·Glass insulation for automobiles becomes universal, all cars will bring to their owners the best of all-around insulation against heat, cold and airborne sound.

Our Detroit office will be glad to give you more information on quality automotive insulation—610 Fisher Building, TRinity 5-0080. Or write: Libbey·Owens·Ford Glass Company, Fiber·Glass Division, 664 Wayne Building, Toledo 3, Ohio.

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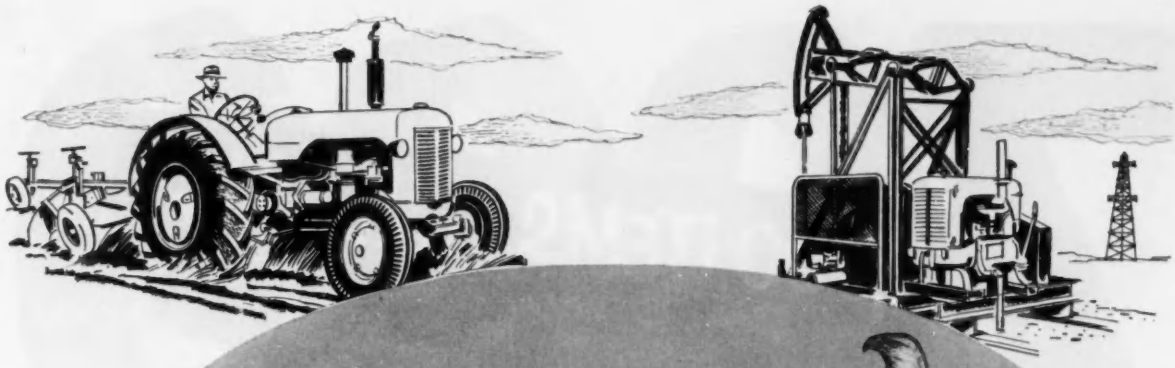
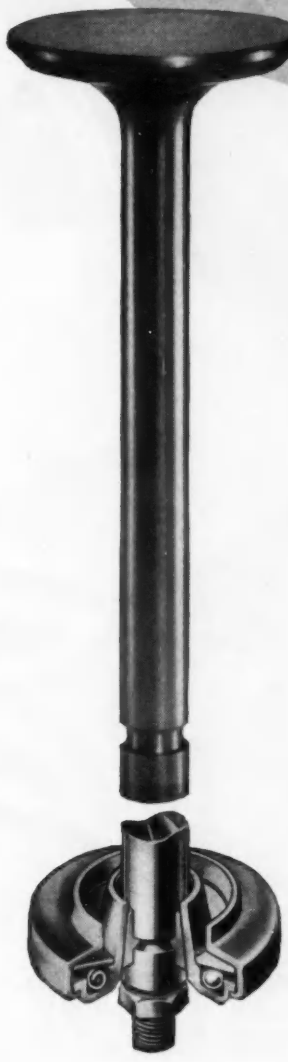


ANOTHER FAMILIAR NAME...

AND A USER OF

THOMPSON VALVES



Since 1842, the famous Case eagle has stood outside hundreds of farm implement stores grasping the globe in its claws.

Today, this same eagle and his globe are on the Case engines which drive Case tractors and power everything from oil well pumps to electric generators.

Thompson engineers work with J. I. Case to design and produce the best valves for the service requirements. Thompson manufacturing facilities provide J. I. Case with the best valves and Thompson "Rotocap" valve rotators for all models of Case engines.

Take a tip from J. I. Case and other famous engine builders . . . count on Thompson for engineering leadership in valves and valve rotation.

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JIG ALIGNMENT TELESCOPE—This K&E instrument can align a jet plane's wings to within a thousandth of an inch. It establishes optically a line of sight from which measurements can be made and parts positioned with a degree of precision not otherwise possible.

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more horsepower a problem?

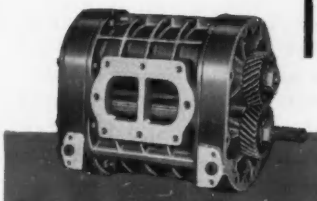
less weight per horsepower a problem, too?

There's an easy way to keep pace with the race for more engine horsepower . . . without adding weight per horsepower, without sacrificing valuable space. *Specify Miehle-Dexter Superchargers.* You'll register a big gain in horsepower—up to 50% or more —and the additional investment in equipment will be far less by comparison with other methods.

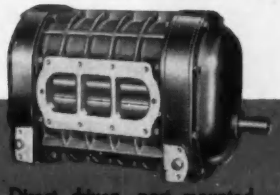
And when you put M-D Superchargers on your engines you're assured of efficient operation plus long life and low maintenance service. Exclusive M-D features make this possible. Result: dividends in fuel economy and maintenance costs.

On small jobs as well as large, M-D engineers will be glad to work with you—to help you get the exact size and type of supercharging equipment for your purpose. Write for technical brochure with specifications and performance data.

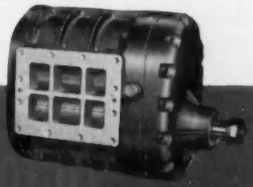
MIEHLE-DEXTER SUPERCHARGERS
are engineered to match your exact requirements



Typical direct driven, flange mounted M-D Supercharger. Develops 350 c.f.m. at 10,000 r.p.m. Other models with capacities to 4,000 c.f.m. available.

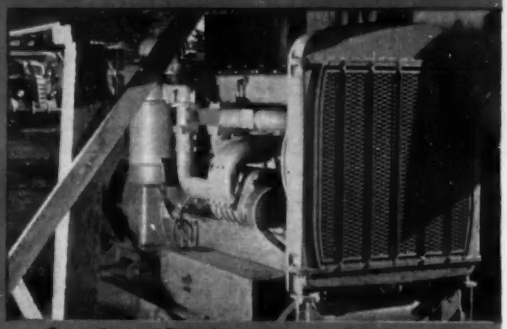


Direct driven, port mounted, Model 37100. Maximum 920 c.f.m. at 7000 r.p.m.



Belt driven, port mounted Model 5511 develops 1250 c.f.m. at 4000 r.p.m.

Supervisors at an Arizona pit mine report big, fast-moving M-D supercharged Diesel trucks climb stiff grades with power aplenty . . . sharply cut maintenance costs in moving overburden.



Supercharged Diesel power pays off in this rock crushing plant. The M-D Supercharger puts 50% more horsepower in the engine . . . reduces weight per horsepower by 20%. Easier portability.

md

MIEHLE-DEXTER SUPERCHARGER

DIVISION OF THE DEXTER FOLDER COMPANY
100 FOURTH STREET • RACINE, WISCONSIN

Trust M-D Superchargers for internal combustion engines . . . use them for blower and air compressor operations, too.

Improved Dual Sealing... with Single Seal Economy

New 2-lip design with more effective sealing surfaces makes this the modern replacement specification for compound element seals . . . giving increased sealing efficiency at minimum cost . . . and more compact seal housing.

Made in two types, both with oil-, age-, and heat-resisting Victoprene synthetic rubber elements. Exclusive Victor mechanical and chemical bonding of element and metal case assures permanent single-unit structure.

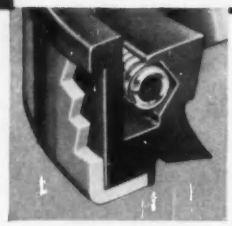
One-piece Victoprene Type K4 and K6 Oil Seals

TYPE K4 FEATURES

1. Dual sealing members for maximum retention of lubricant and exclusion of extraneous matter.
2. Valley between sealing lips retains initial lubricant for minimum friction and longer sealing life.
3. Unitary construction for minimum width requirements. Available in minimum width of 1/4-inch.
4. Available with or without Victoprene rubber on O.D.
5. Available with or without garter spring on primary sealing element.
6. External or secondary sealing lip molded with initial light interference permits satisfactory installation. Upon installation, the primary sealing lip displaces to increase sealing efficiency of secondary member through flex action.

Type K6... without Victoprene on O.D.

For installations not requiring Victoprene on outer periphery and outside face of seal. Otherwise, design of 2-lip sealing element and unitary molded construction are identical with that of Type K4.



Complete information on K4 and K6 seals supplied through your Victor Field Engineer, or on request to the factory. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill.

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Lasting

Performance in Today's Cars Will be Tomorrow's Strongest Selling Point!

Today, more than ever, new car buyers are looking for features that assure long, satisfactory performance. Engine components that contribute to this accomplishment now assume even greater importance as they not only influence today's sales, but become tomorrow's strongest selling point.

For owner loyalty as well as immediate sales, it pays to specify Stromberg* — the carburetor built for *lasting performance.*

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Stromberg* Carburetor Bendix* Electric Fuel Pump Bendix* Folo-Thru Starter Drive

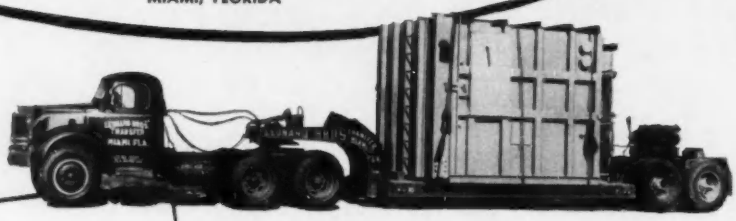
"Wagner Air Brakes

have cut our brake maintenance costs 50%..."

says: George E. Sawyer, FLEET SUPERVISOR

LEONARD BROS. TRANSFER & STORAGE CO., INC.

MIAMI, FLORIDA



LEONARD BROS. TRANSFER & STORAGE CO., Inc.

SPECIALIZED COMMON CARRIERS

Miami Office
2595 N. W. 20th Street
Telephone 64-2661

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LOCAL AND LONG DISTANCE MOVING

Machinery
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Cranes
Winch Trucks
Specialized Equipment

MIAMI, FLA.

Wagner Electric Corporation
6400 Plymouth Avenue
St. Louis 14, Missouri

Gentlemen:

We, of Leonard Brothers Transfer and Storage Co., Inc., are proud of the excellent safety and performance record we have built up over the years. As a specialized common carrier, we are constantly called upon to haul many varied loads that many other fleets are not equipped to handle. It is natural, then, that we insist that every truck and tractor in our fleet be in perfect condition to render our customers fast, economical and efficient service at all times.

Wagner Air Brakes have played a very important part in our maintaining this outstanding record of achievement. We believe you will be interested in knowing that our fleet is 100% equipped with Wagner Air. We know that Wagner Air Brakes are easy to install, quiet in operation and help lengthen the service life of our vehicles. In fact, Wagner Air Brakes have cut our brake maintenance costs 50% and we have never had a single case of pressure failure with the Wagner Rotary Air Compressor.

It is for these reasons that at Leonard Brothers Transfer and Storage Co., Inc. we are continuing our policy of insisting that every vehicle we add to our fleet be equipped with Wagner Air Brakes—they truly give us the safety we demand in an air brake system.

Sincerely yours,
LEONARD BROS. TRANSFER & STORAGE CO., INC.

Geo E Sawyer

George E. Sawyer, Fleet Supervisor

GES:jp

"SERVING FLORIDA AND THE NATION"

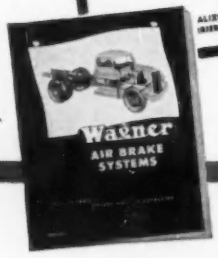
SPECIALIZED MOVERS AND HEAVY HAULERS BETWEEN POINTS AND PLACES IN FLORIDA AND POINTS AND PLACES IN ALL U. S.

It's a fact! Wagner Air Brakes, on the average, require *less* maintenance and render *more* safe, trouble-free over-the-road performance than any other air brake system.

As proof of this dependability, take the word of George E. Sawyer, Fleet Supervisor of Leonard Bros. Transfer and Storage Co., Inc.,—he knows from experience that Wagner Air Brakes are his best buy in substantially lowering brake maintenance costs and in providing an adequate supply of air pressure at all times. In millions of miles of hauling over all types of roads, in all kinds of weather, Wagner Rotary Air Compressors have proven beyond any doubt that they provide exceptionally fast recovery of air pressure. This assures quick, safe, smooth stopping at all times.

It will pay you to include Wagner Air Brakes as standard equipment on the vehicles you manufacture.

Write today for a copy of Wagner Bulletin KU-201. It gives full information on Wagner Air Brake Systems.



WAGNER AIR BRAKE USERS ARE OUR BIGGEST BOOSTERS

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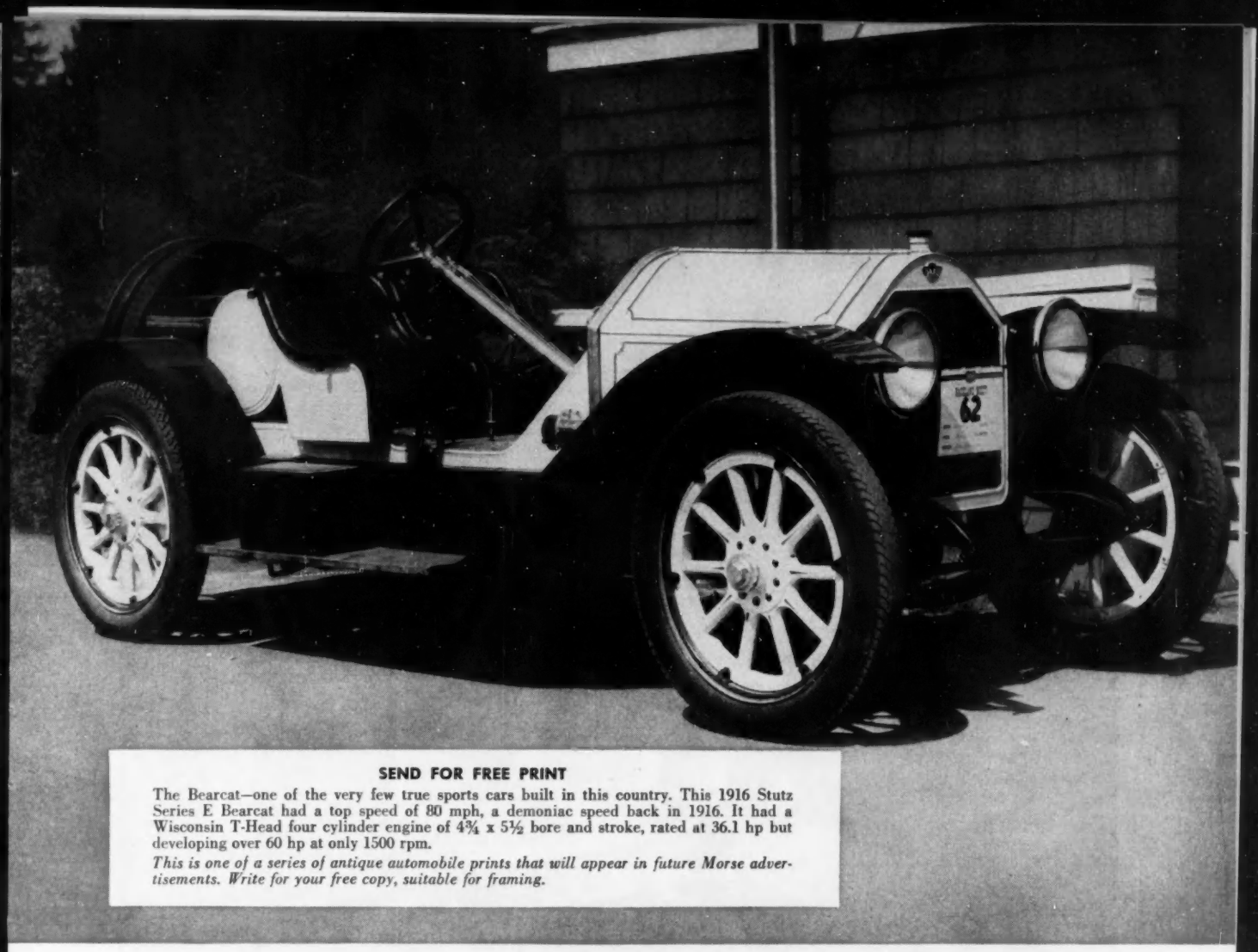
K54-10A



SEND FOR FREE PRINT

The Bearcat—one of the very few true sports cars built in this country. This 1916 Stutz Series E Bearcat had a top speed of 80 mph, a demoniac speed back in 1916. It had a Wisconsin T-Head four cylinder engine of 4¾ x 5½ bore and stroke, rated at 36.1 hp but developing over 60 hp at only 1500 rpm.

This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing.

Proved dependability keynotes Morse Timing Chain Drives

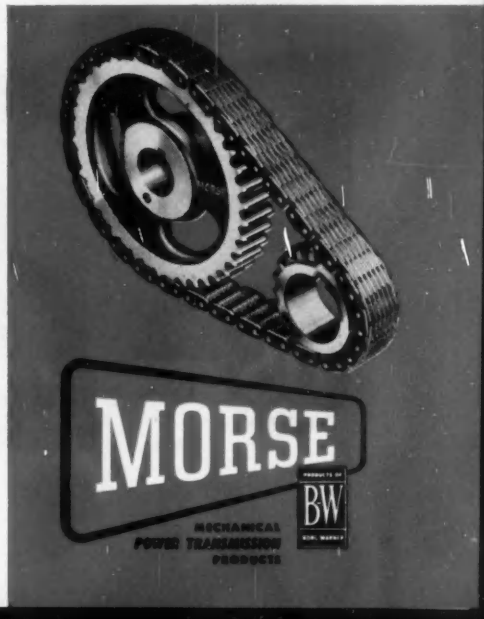
Of the cars now using timing chain drives, twelve out of sixteen—or 74% of those produced, use Morse Timing Chain Drives as original equipment.

Morse is the leading maker of mass-produced, precision-made timing chain drives. Over 58,000,000 of them have given dependable performance in some 116 different makes of cars and trucks.

Rely on Morse for expert engineering service; prompt, on-schedule delivery of parts, too.

Write or call us today. See why it is true that M = TC, Morse means Timing Chains.

MORSE CHAIN COMPANY
7601 Central Avenue
DETROIT 10, MICHIGAN



M=TC

Morse *means* Timing Chains

Right at your elbow...

An automotive executive is always pressed for time. *United States Rubber Company helps lighten the pressure.* Just a fast phone call (Trinity 4-3500) will put at his service "U.S." sales engineers, located in the New Center Bldg., Detroit. These men are the liaison between the automotive man and the "U.S." plant at Fort Wayne. They can instantly put in motion the brains and equipment for solving any problem involving engineered rubber and plastic parts, rubber-bonded-to-metal parts—to make America's cars and trucks run better.

At Fort Wayne is one of the most advanced and extensive laboratories serving the automotive industry. Its scientific personnel, aided by experience, research data and ultra-modern equipment, have one goal —to make your product last longer, function better and more economically.

Save your time. Call Trinity 4-3500, ask for Mechanical Goods Division, or write to address below.

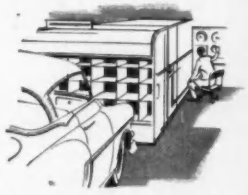
"U.S." Research perfects it
"U.S." Production builds it

US RUBBER

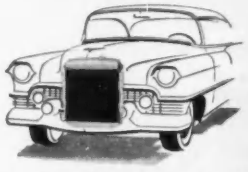
UNITED STATES RUBBER COMPANY

Automotive Sales, Mechanical Goods Division, New Center Bldg., Detroit 2, Michigan

IT'S ALL A MATTER OF DEGREES!



Hot tunnel where scorching blasts of air test the performance of Harrison radiators.



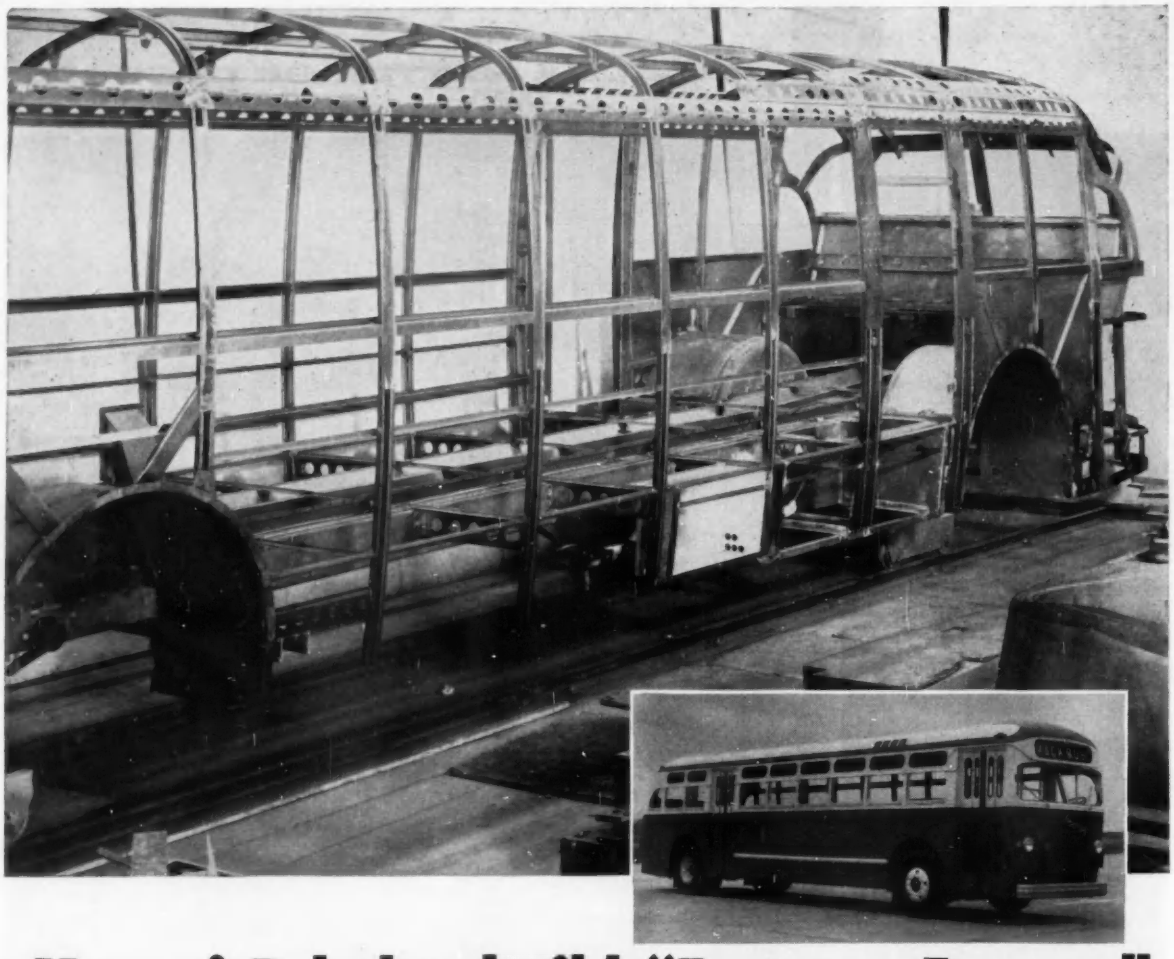
Harrison radiators are standard equipment on the standard of the world . . . Cadillac!

Temperature—bitter sub-zero! *Wind speed*—100 miles per hour! That's the "weather" in Harrison's cold tunnel when we test our car heaters and defrosters. We spray water . . . lots of it . . . on the car windshield. Almost instantly it's ice. We turn on the Harrison heating system. How soon will the heater warm the front and rear seat passengers? How fast will the defroster melt the ice and clear the windshield? These are typical of tests we run every day. Cold tunnel, hot tunnel and dissipator tests—anything to do with temperature. That's because *temperature is our business at Harrison*—world's largest producer of temperature-control systems for automobiles. Our radiators, heaters and defrosters are known for dependability. If you have a hot or cold problem . . . look to Harrison for the answer!

HARRISON RADIATOR DIVISION • GENERAL MOTORS CORP. • LOCKPORT, N. Y.

HARRISON

TEMPERATURES MADE TO ORDER



Mayari R helps build "Fortress Frames" for Mack buses

This slim-ribbed frame might make you wonder why Mack calls it a "Fortress Frame." But appearances can deceive. This modern bus frame is strong as they come, truly a fortress of safety for its riders. Yet it accounts for less than a fifth of the total weight of the bus. A lighter-yet-stronger structure that brings operating and maintenance savings to its owners.

One of the reasons why these Mack buses are standouts is the use of Mayari R steel in the frame. Many of the members — outriggers, roof rails, gussets, cross members — are built of this high-strength, low-alloy steel. Because of its 50 pct higher yield point, Mack can use Mayari R in much lighter sections than structural carbon steel, while providing all the strength required for this rugged kind of service.

More and more, the makers of motor vehicles and trailers are improving their designs with Mayari R steel. They like its strength, yes. They also like its 5-to-6-times greater resistance to atmospheric corrosion. They like the ease with which they can weld it. And they like the way it holds paint — up to 80 pct longer than carbon steels, depending on the type of paint used.

You can get Mayari R in a wide variety of shapes, formed or rolled to your exact dimensions with no material waste. Detailed information on this versatile steel is given in our Catalog 353. A line to the nearest Bethlehem sales office will bring you a copy.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Mayari R *makes it lighter... stronger... longer lasting*

Thousands of America's best mechanics agree...

Sealed Power Chrome Rings

top the field in performance!

For original equipment... for replacement...

There's nothing finer than Sealed Power chrome-faced top compression rings, included in every Sealed Power KromeX Ring Set.

For best oil control, even in badly tapered and out-of-round bores, there's nothing finer than the Sealed Power M-50 Steel Oil Ring with chrome-faced side rails, included in every Sealed Power KromeX Ring Set.

28 leading engine builders use Sealed Power Chrome Rings.

SEALED POWER PISTON RINGS

Sealed Power Corporation

MUSKEGON, MICHIGAN

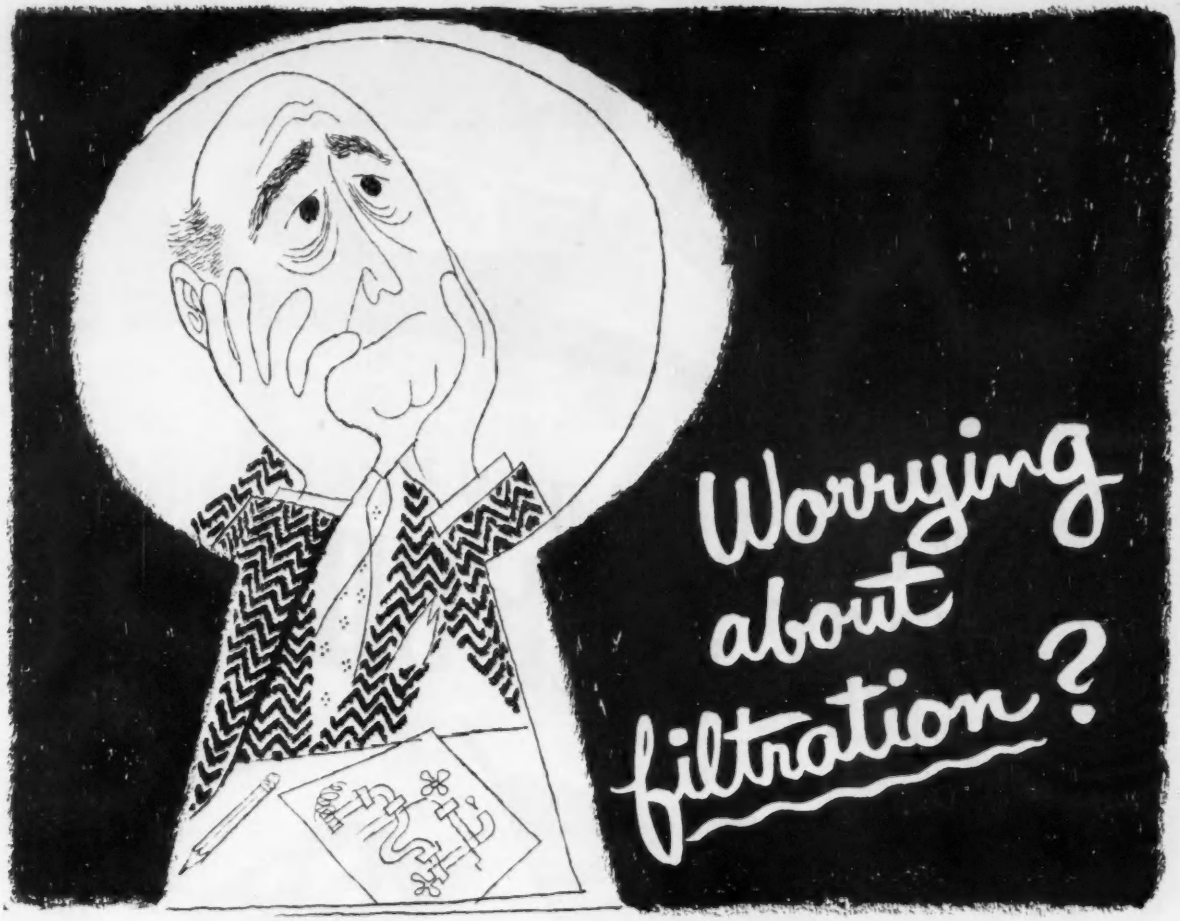
Sole manufacturers of KromeX Ring Sets, MD-50 Steel Oil Ring, Full-Flow Spring, Flex-5 Flexible Oil Ring, and GI-60 Groove Inserts. Leading producer of Automatic Transmission Rings, Power Steering Rings, and Non-Spin Oil Rings.

McQUAY-NORRIS

PISTON RINGS

Since 1910, McQuay-Norris has played a leading role in the piston ring field. This background of more than 43 years experience is available to manufacturers who require engineering and production skills of the highest standard.

McQUAY-NORRIS MFG. CO. • ST. LOUIS 10, MO.



Purolator maintains the world's largest specialized filter research and engineering laboratories

. . . always ready to serve you!

Your filter problems—small or large—are always welcome at Purolator's Engineering Department.

If you find that none of the nearly one thousand types of standard Purolator* filters will fill the bill . . . we'll design one especially for you!

But before you decide on a custom-designed unit, you'll want to study the many kinds of Purolators available on order. The large, illustrated Purolator catalogs are yours for the asking. Just mail us the coupon, indicating which ones you wish.

Whether you need one special filter, or a million of a kind . . . your best source is *Purolator!*

There's a PUROLATOR for every filter need

Lube oil	Air	Foods	Adhesives
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PUROLATOR PRODUCTS, INC.
Rahway, New Jersey and Toronto, Ontario, Canada
Factory Branch Offices: Chicago, Detroit, Los Angeles

PUROLATOR
WORLD'S FINEST OIL FILTER

Here's the KEY to your filter problems—

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Send the following Purolator catalogs:

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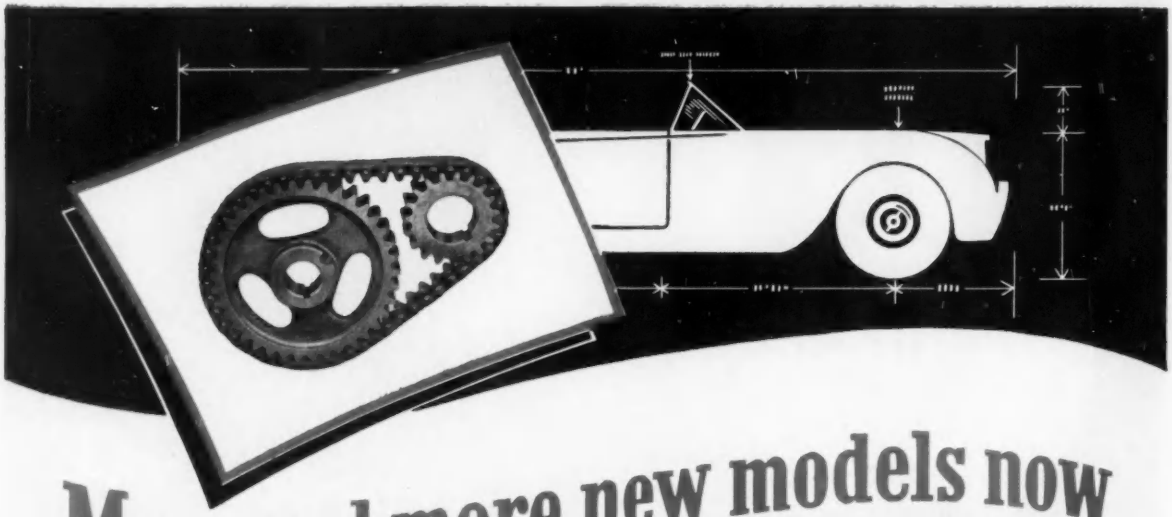
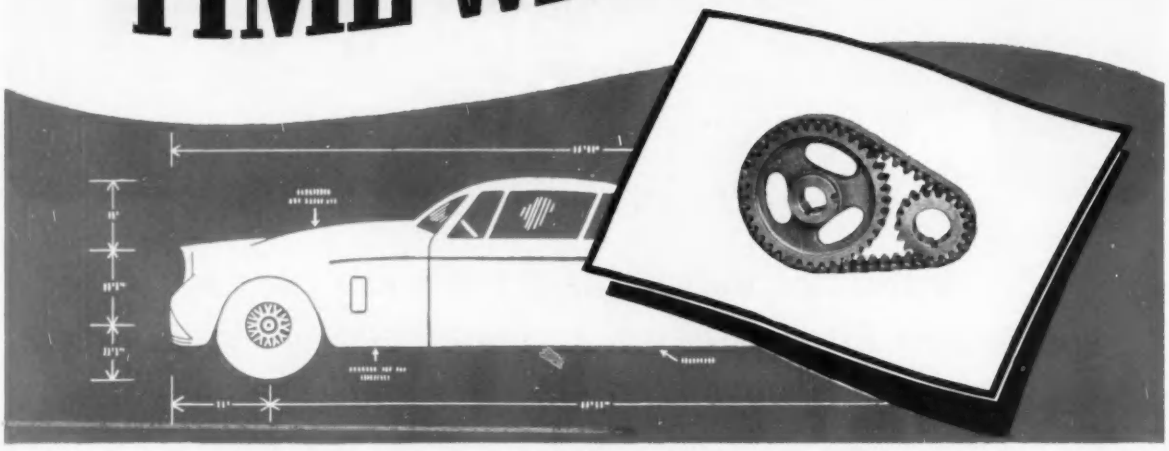


More and more new models now TIME with CHAIN



and LINK-BELT Timing Chain gives you

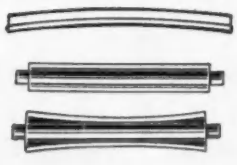
✓ **Automatic joint snugness** ✓ **Smoother operation** ✓ **Longer life**

FOR greater design flexibility plus superior performance, leading automotive manufacturers are swinging to timing chain. Let our engineers show you how this outstanding chain can fit into your latest engine. Engineering and specification details are available in Book 2065.

LINK-BELT

TIMING CHAIN and SPROCKETS

Segmental bushings provide automatic joint snugness



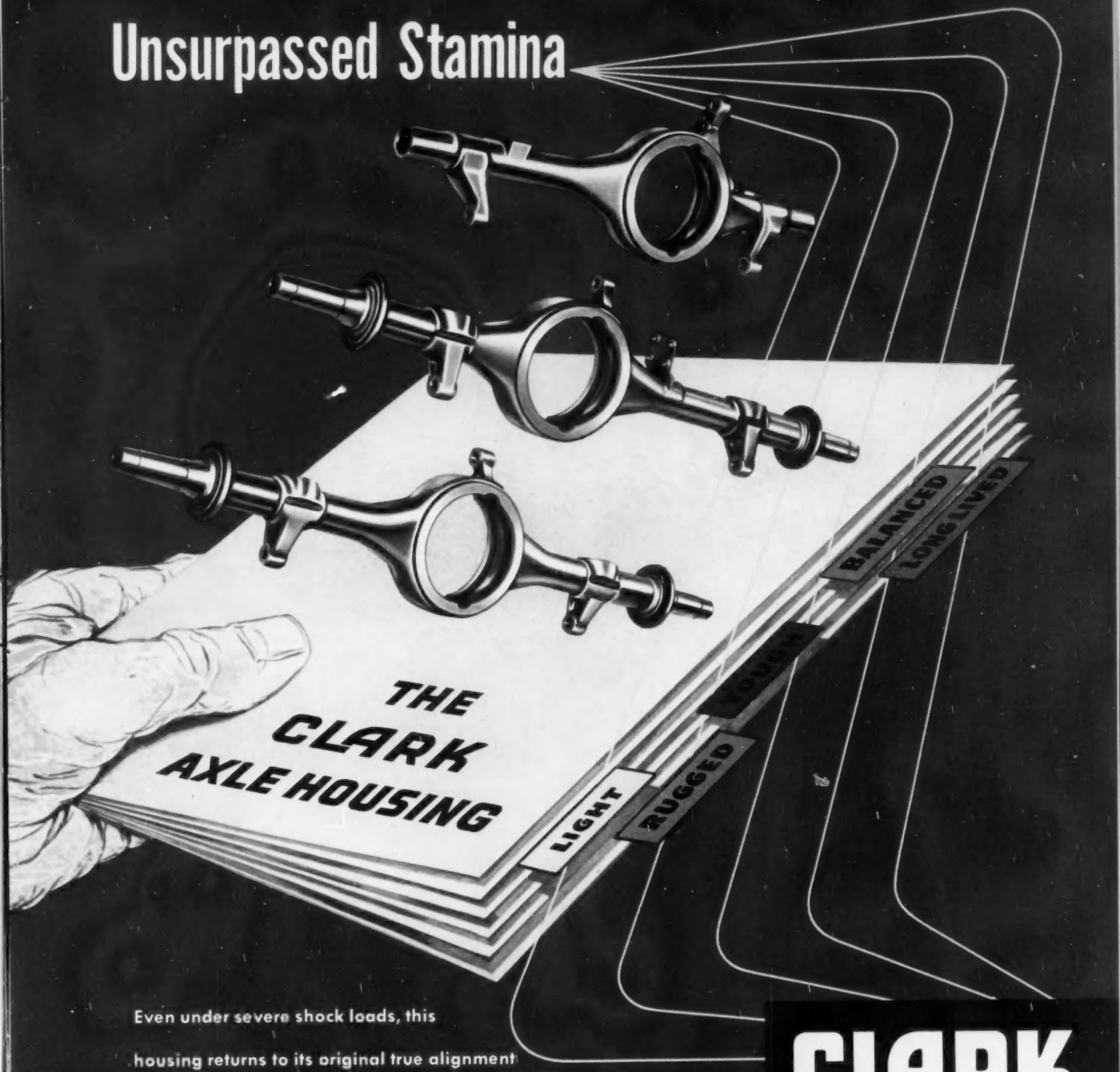
Segmental bushings are made with slight bow.

After initial assembly in chain, bushings are straight.

Bow in bushing acts to keep a snug joint.

LINK-BELT COMPANY: 220 South Belmont Ave., Indianapolis 6, Ind. Offices in principal cities. 13,334

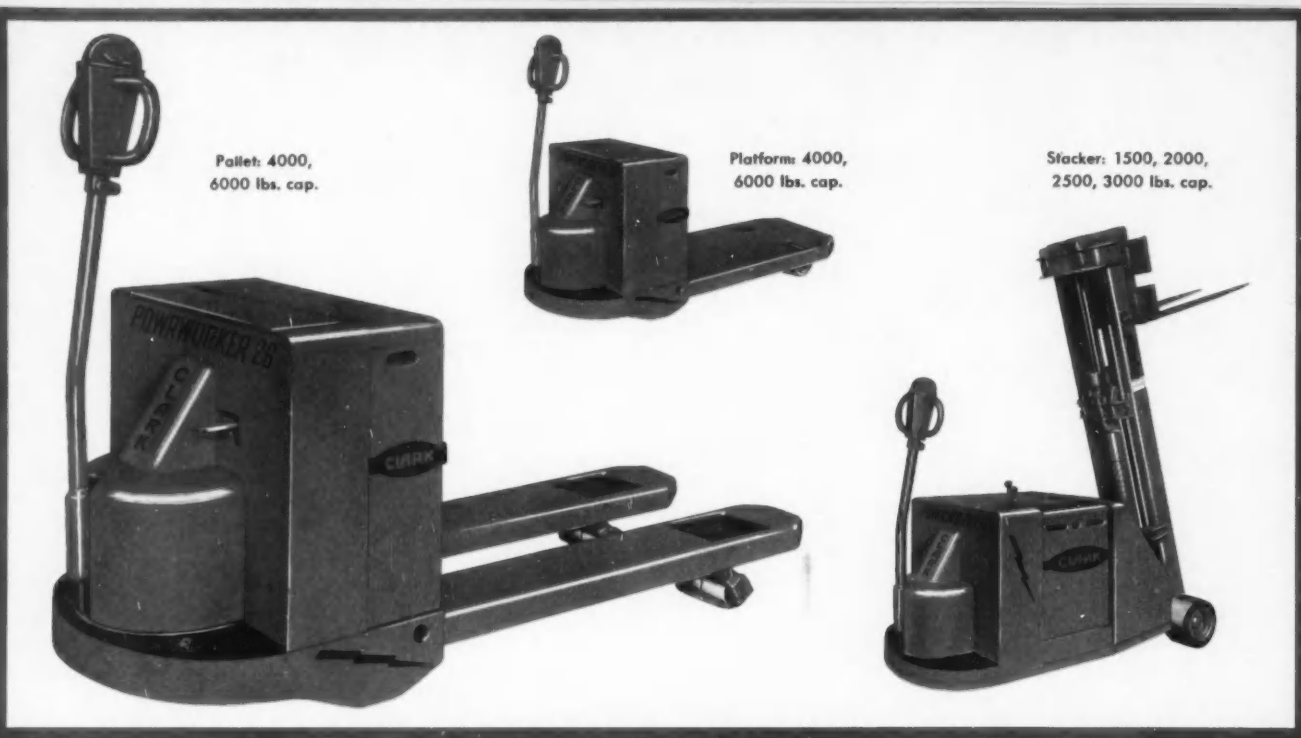
Unsurpassed Stamina



Even under severe shock loads, this housing returns to its original true alignment . . . because it is a one-piece heat-treated forging. A broad range of types and sizes suggests that it's good business to do business with Clark.

CLARK EQUIPMENT

CLARK EQUIPMENT COMPANY, BUCHANAN, Battle Creek, Jackson, Benton Harbor, Michigan



The Clark *POWRWORKER "26"*

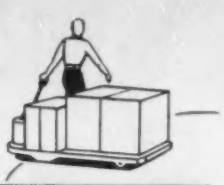
Feature by feature, it's engineered to meet your own handling requirements

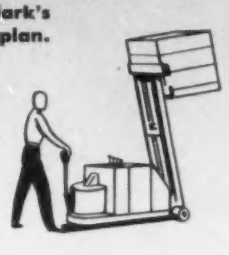
Detailed job-studies in customer plants, warehouses and terminals dictated the features of the POWRWORKER "26". No truck on the market today can match the POWRWORKER'S combination of *user-benefits:*

- **Maximum Maneuverability** — Only 26″ longer than the load, the shortest standard truck on the market.
- **Light Weight**—Completely fabricated construction combines maximum strength with least weight.
- **Stability**—Close-to-the-floor, low center of gravity.
- **Great Efficiency**—Double reduction of spur gears gives maximum ton-miles at least power cost.
- **Balanced Load Distribution**—Double lift cylinders for smooth lifting and lowering.
- **Safety**—Deadman switch cuts power when brake is applied, handle automatically returns to brake-position.
- **Easy to Service**—All operating units accessible without lifting or dismantling. Drive wheel tire is quickly demountable.

We invite you to compare the 1954 POWRWORKER with any truck on the market! For details, call your local Clark dealer, listed in the Yellow Pages of your phone book.

Ask your Clark dealer about Clark's low-cost Pay-As-You-Go leasing plan.





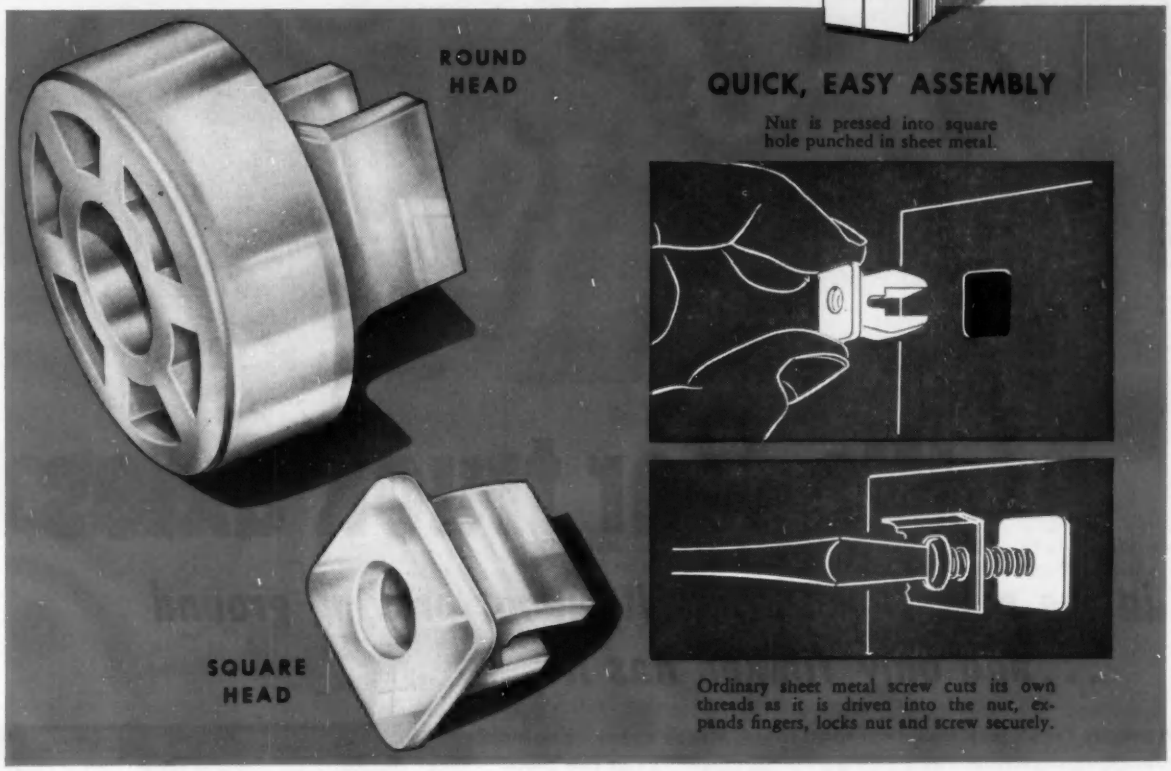
PRODUCTS OF CLARK: TRANSMISSIONS • DRIVING AND STEERING AXLES • AXLE HOUSINGS • TRACTOR DRIVES • LIFT TRUCKS • TOWING TRACTORS • ROSS CARRIERS • POWRWORKER HAND TRUCKS • EXCAVATOR CRANES • TRACTOR SHOVELS • ELECTRIC STEEL CASTINGS • GEARS AND FORGINGS

CLARK EQUIPMENT

POWRWORKER SECTION
Industrial Truck Division
CLARK EQUIPMENT COMPANY
Battle Creek, Michigan

How many ways can **you** use

DOT PLASTIC *snap in* NUTS?


ROUND HEAD
SQUARE HEAD
QUICK, EASY ASSEMBLY
Nut is pressed into square hole punched in sheet metal.
Ordinary sheet metal screw cuts its own threads as it is driven into the nut, expands fingers, locks nut and screw securely.

United-Carr's new self-locking, plastic nut is designed for blind application and can be used with all types of metal finishes without scratching or chipping the surface. Its plastic fingers provide rigid anchorage yet will not mar paint, polished metals or even porcelain.

Inexpensive sheet metal screws cut their own threads and expand the nut's fingers as they are driven, locking both nut and screw tightly in place. Screws can be removed and replaced several times without damage to the nut.

DOT plastic snap-in nuts are electrically non-conductive and provide a high degree of insulation against heat transfer. For all practical purposes, they also provide an effective vapor seal.

Available in several styles and sizes. Write for full information and samples or contact your nearest United-Carr representative.

UNITED-CARR FASTENER CORP.

CAMBRIDGE 42, MASSACHUSETTS

MAKERS OF DOT FASTENERS

We tear truck axles to

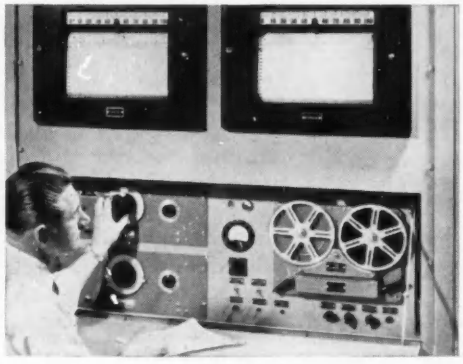
in the new Timken-Detroit indoor proving ground ... and only Timken has it!

We smash, twist, jerk and over-load them. Match every imaginable hauling situation. Then add a few ruinous tricks of our own.

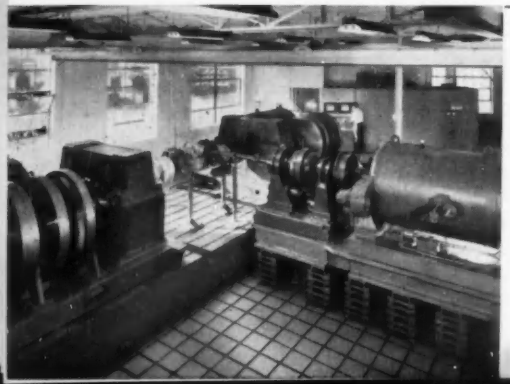
It's done on purpose. So we can tell you in advance that a Timken-Detroit axle can take a more brutal beating on the job it was designed for than any other axle made.

To prove it, we condensed a multi-thousand acre proving ground into one room. In it, our engineers can apply 50 years of experience in building axles for trucks, buses and trailers. Here axles and gearing are subjected *indoors* to any possible *outdoor* hauling condition. Axle performance is measured and analyzed under absolute scientific control.

Such research means longer axle life; less maintenance, repairs and down-time; lower operating costs; fatter profits. No wonder Timken-Detroit axles are the choice of manufacturers and owners everywhere!



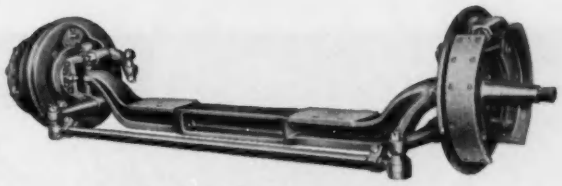
This is our "truck driver," he works in the "Torture Chamber." Above him are graphs showing speed and torque performance under any operating condition he chooses . . . soft ground at full load . . . mountains . . . express highways or side roads. With special dials, recorders and electronic devices, he actually *drives* the axle with scientific accuracy from his chair!



How TDA proves axle quality in this "Torture Chamber."

We take one of our axles and put it on the "block". . . then duplicate the roughest hauling condition, hour after hour, day after day . . . such as simulating 500,000 miles of toughest driving in just a few days. Or we "dream up" a test like going up hill with a full load at 45 m.p.h. from California to New York—*non-stop*. There is no other axle-testing like it in the world!

He's on the highway. He needs Timken-Detroit axles. Identical axles in our indoor proving ground are subjected to tests so rugged they're comparable to a half-million miles or more of high-speed, nonstop, uphill-downhill operation with capacity load . . . hour after hour, 24 hours a day, for days! Only Timken-Detroit "Torture-Tested" axles can take this brutal treatment—to assure top performance—make more money per load!



Timken-Detroit Front Axles

Here is easy, positive steering control. A little man can handle a large rig with TDA front axles as easily as a big 210-pound, six-footer, at fast or slow speeds . . . on smooth or rough roads. No wheel kickback. Tractor hook-ups have smallest possible turning radius—greatest maneuverability.

Timken-Detroit Hypoid Gearing

Hypoid gearing for truck axles was pioneered by Timken-Detroit. And only Timken-Detroit has Hypoid gearing in a complete "family" of 7 basic axle capacities—in the entire range of medium and heavy-duty requirements. This advanced-related design incorporates the same features of construction and interchangeability in a choice of 3 types of Hypoid final drives using the same axle shafts and housing—single-speed; single-speed double-reduction; and two-speed double-reduction units.

Timken-Detroit Tubular Trailer Axles

Famous for their light weight. Produced in the largest, most modern axle plant in the world. Lightweight Fabricated Brake Shoes with Econoliners for greater wear, longer service. Alloy steel spindles electrically welded to tubular housing—with welding guaranteed for the life of the axle. Lightweight Nylon Bushings in Brake Camshaft Assemblies.

pieces

TIMKEN Detroit AXLES

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

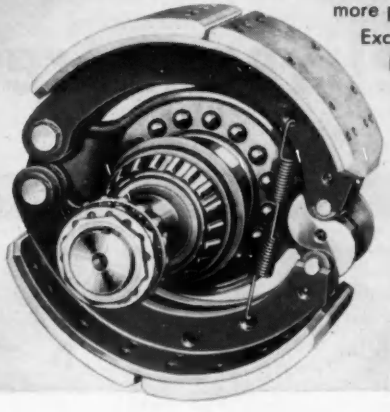
The Accepted D A Standard

TRADE MARK REGISTERED

"TORTURE-TESTED"
to Save Money on the Job

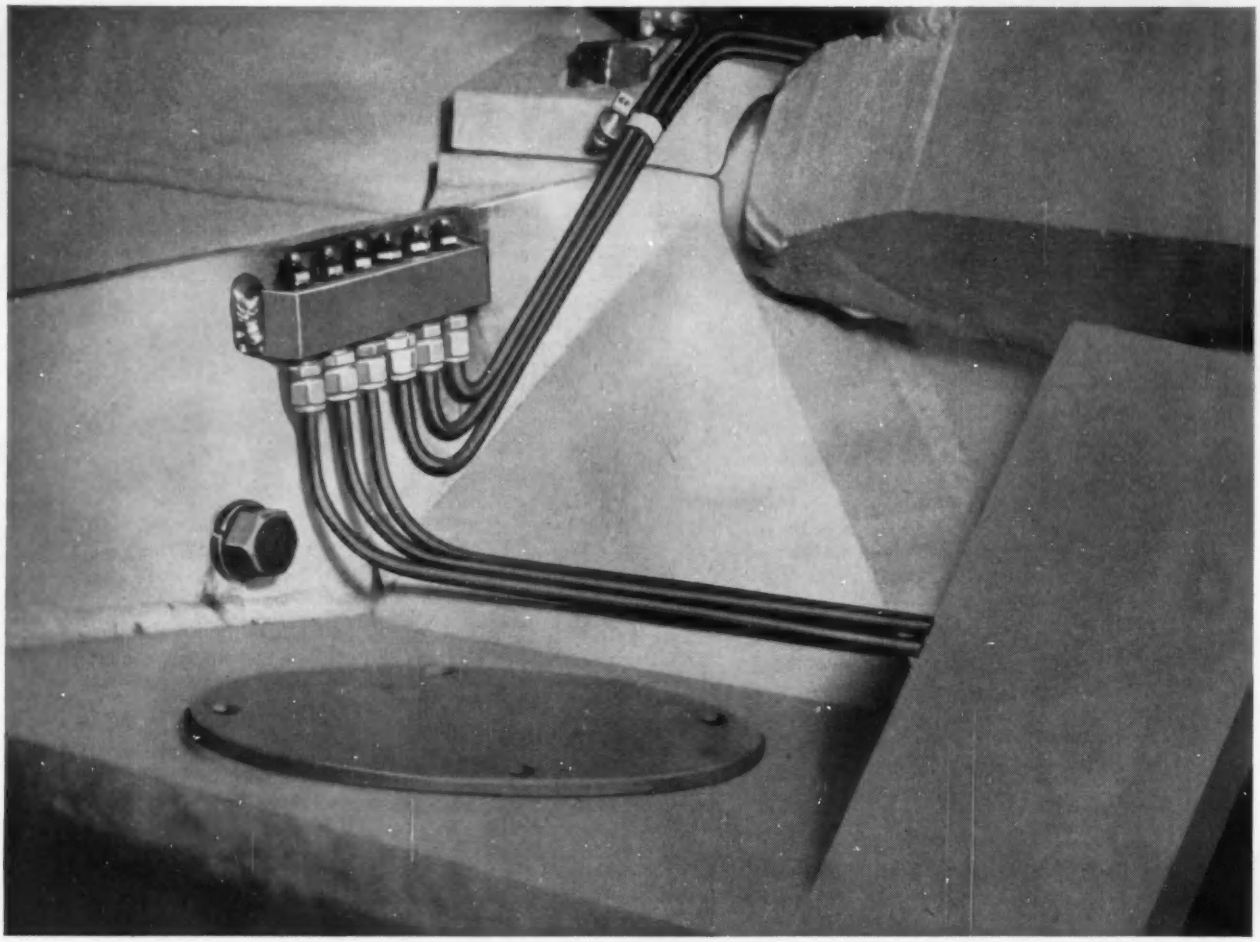
WORLD'S LARGEST MANUFACTURERS OF AXLES FOR TRUCKS, BUSES AND TRAILERS

New TDA brake shoes save up to 40 lbs. per axle



- Lightweight, pressed steel construction to give you more payload plus long wear and safety.
- Exclusive ¾" TDA "Econoliner" brake liners held rigidly by 12 deep-set rivets per block—*not bolts*. Liners are thickest at center where greatest wear occurs—taper down at ends. Result—longer wear, greater stopping ability. New cam roller mountings never seize or brinnel. Light nylon camshaft bearings wear up to 4 times as long! It's America's new brake shoe!

Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York • Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania



Bundy-fabricated ball-and-socket lubrication lines of leakproof Bundyweld help keep C Tournapulls on the job – all the time.

Bundyweld helps powerful earthmover deliver more yardage

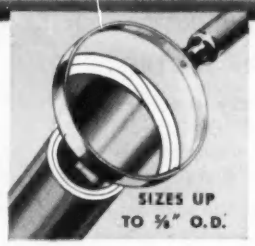
WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

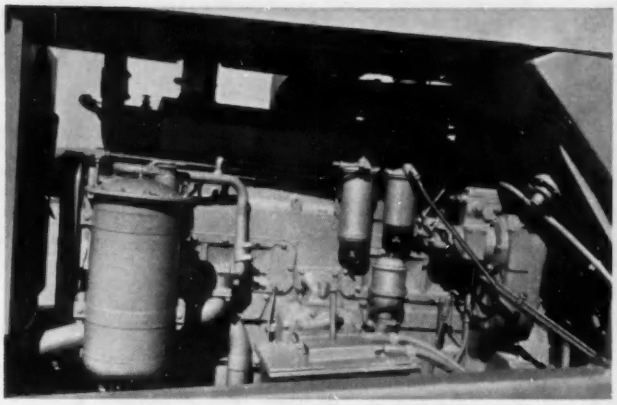
continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.



← **NOTE** the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.



Fuel system in this powerful earthmover must be leakproof; the manufacturer uses fuel lines of Bundyweld.

New C Tournapull is a rugged, 16-yard-capacity, 19-ton-load unit with fingertip electric control.

Dependable Bundyweld functions faithfully as LeTourneau-Westinghouse earthmover hauls through sand, snow, mud without stalling

Whenever tons of earth must be moved efficiently, economically—through all kinds of adverse weather and surface conditions—the LeTourneau-Westinghouse Company's C Tournapull prime mover and scraper is on the job.

Advanced design and engineering features contribute largely to the C Tournapull's impressive record in the earthmoving field. Naturally, the manufacturers insist on a top-notch, always-dependable tubing for this top-notch, always-dependable machine. *That's why they specify Bundyweld.*

The rugged C Tournapull calls for many tubing applications, including fuel lines, lubrication lines, transmission lines. These lines must be absolutely leakproof; stand up under punishing vibration and heavy wear; have high tensile strength, high fatigue limit. *That's why they're made of famed Bundyweld Tubing.*

And LeTourneau-Westinghouse engineers and production people appreciate the fact that this quality tubing is shipped to them clean and bright, ready for use; that it's carefully inspected, carefully packaged, delivered *on schedule,* exactly as specified. *Just one more reason they vote for Bundyweld.*

Of course, if your operation requires fabricated tubing parts, whether simple or complex, we're equipped to produce them quickly, economically, exactly to specifications. No matter what your tubing needs, it will pay you to talk over your application with a Bundy tubing specialist. Call, write, or wire Bundy Tubing Company, the world's largest producer of small-diameter tubing.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Bundy Tubing Distributors and Representatives: ***Bridgeport, Conn.:*** Korhumel Steel & Aluminum Co., 117 E. Washington St. • ***Cambridge 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Los Angeles 58, Calif.:*** Tubesales, 5400 Alcoa Ave. • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave., South • ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 181 Fleet St. East.
Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

Some sales aids are still in crystal balls—

but—**The SEATS of the Future are HERE!**

MAYBE tomorrow will bring you the greatest new feature that ever sold a car. Maybe. But if you're interested in *today*—feast your eyes on this richly sculptured AIRFOAM seat.

Strictly custom? You'd think so—but seats like this are helping sell cars of *many* price ranges right NOW!

They're doing that job because people want AIRFOAM—and plenty of it—in seats and backs and armrests, front AND rear.

They're doing that job because people want the advanced styling made possible by AIRFOAM design-engineering!

And people are *getting* these things, right NOW. Are they getting them in your line, too? Goodyear, Automotive Products Dept., Akron 16, Ohio.

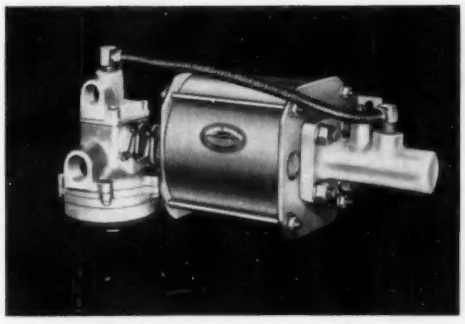
MORE AIRFOAM IN YOUR LINE—MEANS MORE NAMES ON THE DOTTED LINE!

Airfoam—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Airfoam MADE ONLY BY **GOODYEAR**

THE WORLD'S FINEST CUSHIONING

Easy does it



with BORG-WARNER "FEATHER TOUCH" POWER BRAKES

Designed for Service Shop Installation on Most '46 to '54 Model Cars

By now, most car owners are aware of the many advantages of power brakes. Smooth, instant response to light pedal pressure . . . quicker, shorter, surer stops . . . less strain, less fatigue, greater driver comfort.

But up until recently, power brakes were available only as factory installed optional equipment on certain makes of new cars. Now—thanks to Borg-Warner engineering—B-W "Feather Touch" Power Brakes can be installed in an hour or so on most '46 to '54 models of all popular makes of cars.

As with scores of other Borg-Warner products, this new unit is engineered out of deep experience with the automotive industry's high standards. It has a minimum of wearing parts, requires no lubrication, is unaffected by changes in climate. And it is the industry's smallest, most compact unit, low in price, dependable in performance.

Designed and built by B-W's Marvel-Schebler Products Division, the new "Feather Touch" Power Brake is another example of Borg-Warner's "design it better—make it better" tradition. One more in a long list of B-W contributions to the driving safety, comfort and pleasure of the motoring public.

B-W engineering makes it work B-W production makes it available

ENGINEERING B-W PRODUCTION

Almost every American benefits every day from the 185 products made by

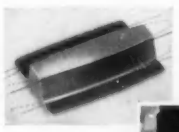
BORG-WARNER

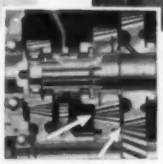
THESE UNITS FORM BORG-WARNER, *Executive Offices, Chicago:* ATKINS SAW • BORG & BECK • BORG-WARNER INTERNATIONAL • BORG-WARNER SERVICE PARTS • CALUMET STEEL • CLEVELAND COMMUTATOR • DETROIT GEAR • FRANKLIN STEEL • HYDRALINE PRODUCTS • INGERSOLL PRODUCTS • INGERSOLL STEEL • LONG MANUFACTURING • LONG MANUFACTURING CO., LTD. • MARBON • MARVEL-SCHEBLER PRODUCTS MECHANICS UNIVERSAL JOINT • MORSE CHAIN • MORSE CHAIN CO., LTD. • NORGE • PESCO PRODUCTS • REFLECTAL • ROCKFORD CLUTCH SPRING DIVISION • WARNER AUTOMOTIVE PARTS • WARNER GEAR • WARNER GEAR CO., LTD. • WOOSTER DIVISION

Why more and more truck manufacturers are shifting to FULLER

Demand from the field

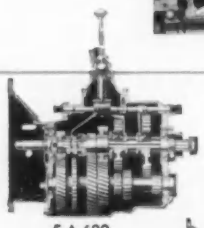
Ask the driver—the man who has to maintain engine rpm to meet round-trip schedules. Ask the mechanic—the man who has to keep the truck *on the road*. Ask the owner—the man who has to pay the bill if the transmissions fail. They'll tell you they want a Fuller Transmission . . . *for Fuller has the features for more profitable trucking.*



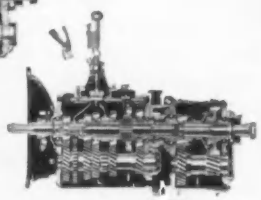


Fuller design features

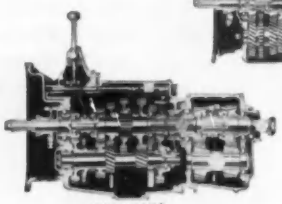
Open up a Fuller Transmission . . . and you can see the "extras" Fuller provides. Take a Fuller-equipped truck out on the road and *feel* it perform. Constant mesh, helical gears mean easier, faster shifting in forward speeds. Crowning the gear teeth prevents stress . . . longer life for Fullers. Shot peening reduces metal fatigue . . . less material failure.



5-A-620



R-Y5-C ROADRANGER



10-B-1120

110 Models—100 to 400 hp

Specify a Fuller Transmission for your on- or off-highway units and get a transmission *matched* to your load and road conditions . . . that will provide the right ratios for your job. Specify a transmission *designed to deliver* more effective horsepower . . . a Fuller Transmission.

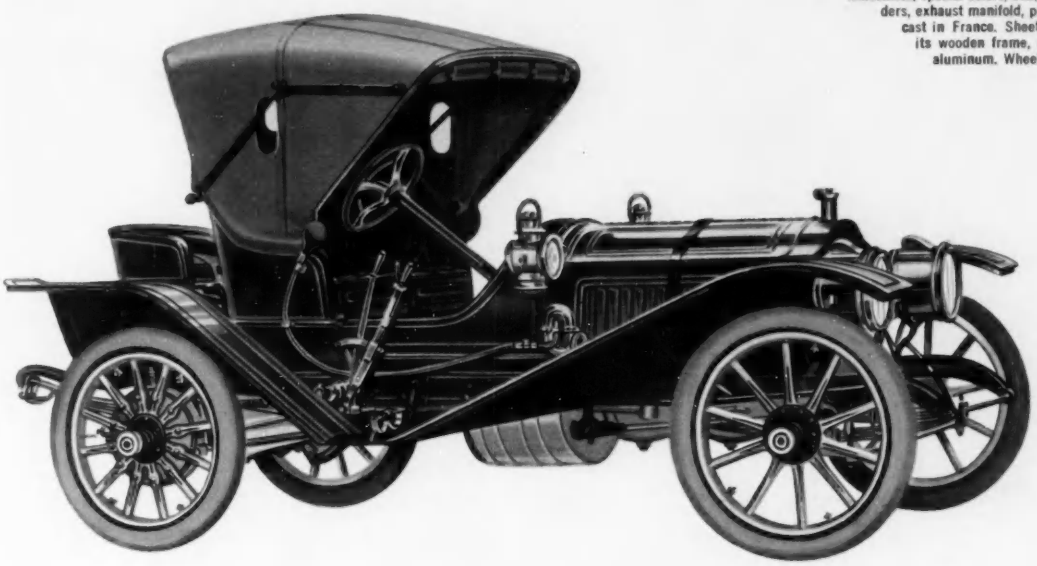
really
where horsepower goes to work

Fuller TRANSMISSIONS®

FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO, MICHIGAN

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Western Dist. Branch (Sales & Service, All Products), 641 E. 10th St., Oakland 6, Cal.

Your 1909 Packard "Thirty" Runabout sold for $4200, with top, windshield, special colors, etc., extra. The car's four cylinders, exhaust manifold, pistons and piston rings were cast in France. Sheet aluminum panels covered its wooden frame, and fenders were made of aluminum. Wheelbase 123½", tires 36" x 4".



Ask the man who owns one.....

THIS was more than an automobile. To many a successful man it was a symbol of his success. Frequently, from the mere fact of possession, it served to project the personality of its owner in a way that filled a soul-satisfying need.

Who, then, could measure the value of a 1909 Packard? Wisely, the men who made and sold them said . . . "Ask the man who owns one . . ."

We have come to believe that its builder poured his heart into the making of this fine car. His heart, his creative spirit, became a part of the car.

Thus, the proud owner of a Packard found in his automobile a visible expression of his own creative nature . . . an expression in line . . . and color . . . in pleasing line . . . and warm, appealing color.

R-M

REG. U.S. PAT. OFF.

RINSHED-MASON COMPANY

DETROIT 10, MICHIGAN
ANAHEIM, CALIFORNIA
WINDSOR, ONT., CANADA

America's leading manufacturer of fine lacquers, enamels and undercoats for automobiles, trucks, farm equipment, appliances, and numerous other products of industry. We invite your inquiry.

- for engine capacities from 135 to 600 lbs.-ft. torque
- single or double plate
- plate sizes from 9 to 17 inches

LONG

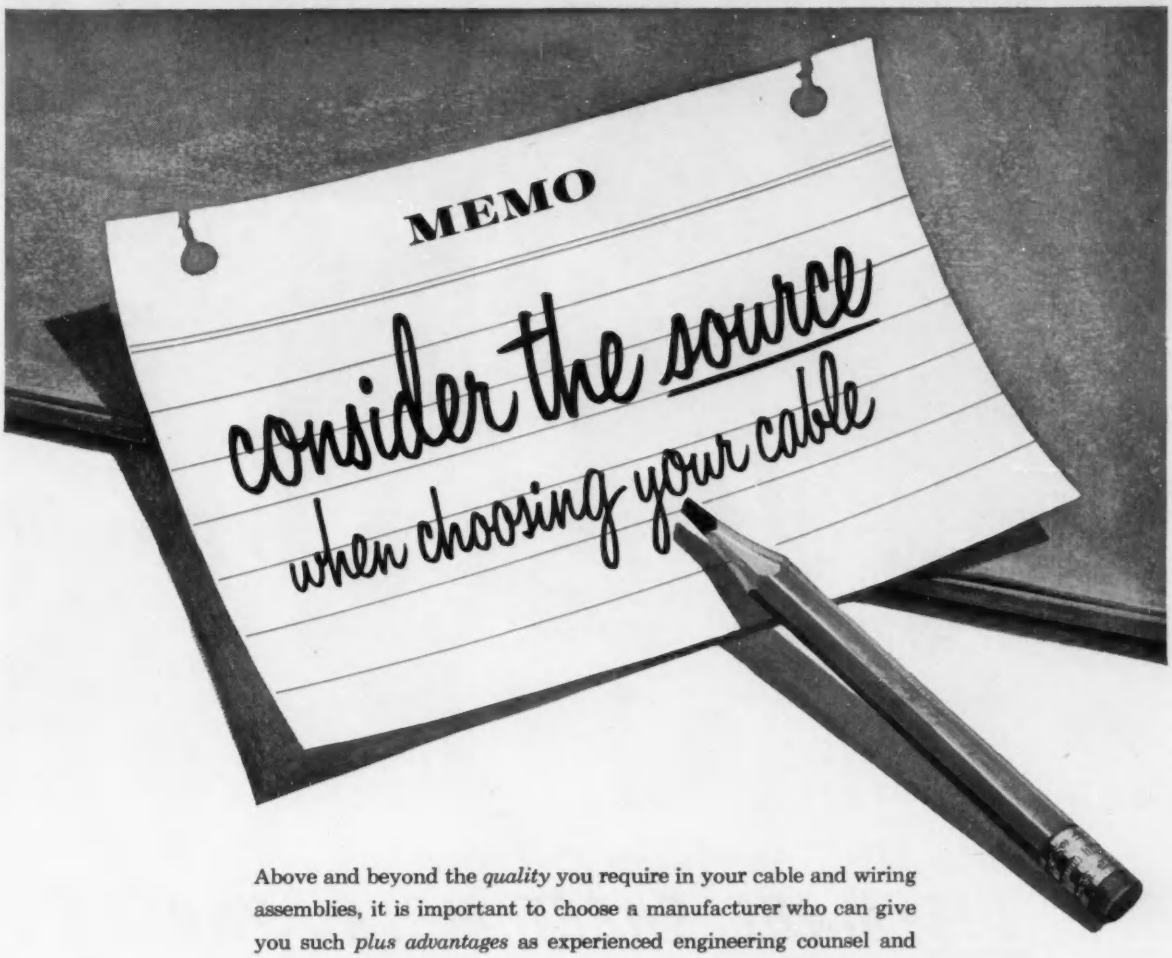
. . . for heavy-duty clutch requirements

Insistence upon the finest quality has been an inflexible practice at the Long Manufacturing Division for over 50 years. Long quality is proven with the millions of Long Clutches being road tested every day on cars, trucks, buses, and tractors.

LONG MANUFACTURING DIVISION • BORG-WARNER CORPORATION

Detroit 12, Michigan, and Windsor, Ontario

CLUTCHES • RADIATORS • TORQUE CONVERTERS • OIL COOLERS



Above and beyond the *quality* you require in your cable and wiring assemblies, it is important to choose a manufacturer who can give you such *plus advantages* as experienced engineering counsel and on-time delivery. Often it is intangibles such as these that help keep your production lines going.

Consider Packard as a source

The wide use of Packard cable and wiring assemblies on America's foremost automotive vehicles, aircraft and appliances is your assurance of top quality. Packard's vast manufacturing capacity—more than 7,000,000 feet of finished cable and 800,000 wiring assemblies each day—is your assurance of regular delivery in any quantity you demand. And Packard's engineering ability assures cable and wiring assemblies correctly designed and fabricated to suit your requirements. These are factors that often result in worthwhile savings to Packard customers.

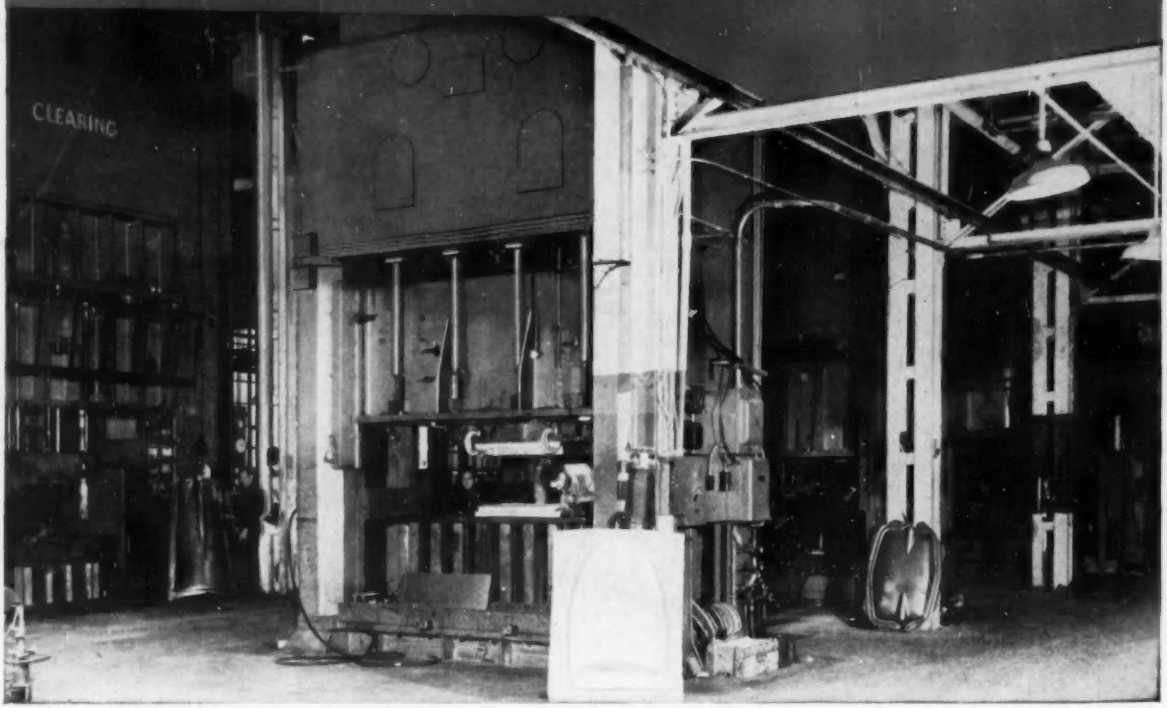
Packard

REG U.S. PAT. OFF. TRADE MARK

Packard Electric Division • General Motors Corporation • Warren, Ohio

AUTOMOTIVE, AVIATION AND APPLIANCE WIRING

FOR PROTOTYPE PARTS . . .



Allied's Allite Division Offers . . .

DIE-MADE SHEET METAL PARTS!

If you are following the example of a number of America's leading industries in building complete and accurate product prototypes before establishing definite manufacturing procedures, here is a time- and money-saving service which has become an important part of many such programs.

Take Allied draw and form dies for producing prototype parts . . . such dies are made of either plastic or Allite (zinc alloy) depending on the number or type of pieces required. Cost and delivery is considerably less than that of production dies, yet accuracy is comparable in every way. Upon completion of the dies, prototype stampings are produced in Allied's press equipment, then trimmed, flanged and pierced by hand.

These prototype parts are another of Allied's die and stamping services which result in a dollar savings to you. We would appreciate your inquiry, or better yet a personal visit to our Plant Four in Hillsdale, Michigan, to show you such operations.

Other Allied Products { SPECIAL COLD FORGED PARTS • STANDARD CAP SCREWS • HARDENED AND PRECISION GROUND PARTS • R-B INTERCHANGEABLE PUNCHES AND DIES

PRECISION • EXPERIENCE • DEPENDABILITY
ALLIED PRODUCTS CORPORATION

ALLIED PRODUCTS CORPORATION

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Hillsdale, Mich.

IF YOUR PRODUCT DESIGN INVOLVES HYDRAULIC POWER

specify

PESCO *Pressure Loaded* PUMPS

There's only one *best* hydraulic pump for any job—*and it's PESCO!* On thousands of hydraulic applications with capacities up to 60 gpm and pressures to 3000 psi, PESCO Pressure Loaded PUMPS have proved to be the *one best* answer to continuous peak performance.

When your requirement calls for dependable hydraulic performance with life-long peak efficiency, you'll want PESCO. And when your problem involves hydraulic power, you'll want to make use of the outstanding PESCO Hydraulic Engineering Service—with specialists in YOUR hydraulic problems. It's yours without obligation—simply call or write the Home Office, Bedford, Ohio.

DEPENDABLE PERFORMANCE
•
CONTINUOUS NEW PUMP EFFICIENCY
•
AUTOMATIC ADJUSTMENT FOR WEAR
•
LESS UNIT SPACE REQUIRED
•
LOWEST LIFETIME COST

Call or write the Home Office, Bedford, Ohio for full information on these outstanding PESCO PRODUCTS
HYDRAULIC PUMPS • POWER-PACKAGES
HYDRAULIC MOTORS • ELECTRIC MOTORS
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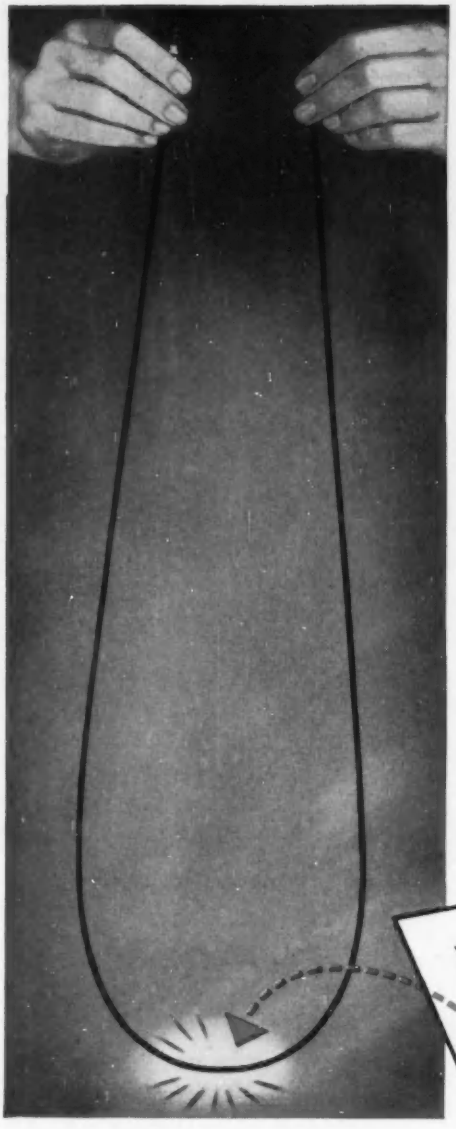
engineering Pesco production
PRODUCTS DIVISION

PRODUCING THE BEST IN HYDRAULIC EQUIPMENT AND ELECTRIC MOTORS

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

FIRST and FOREMOST!



The Whip-Free Flexible Cable was Developed by AC

For 27 years AC has been a forefront name in the manufacture of flexible shafts for automotive applications. One reason for this preference was the AC engineering victory over the inherent "whip" in multiple wire-wound flexible cable, which made instrument needles wobble disconcertingly.

Problem was to preserve flexible cable strength while normalizing by heat treatment to eliminate the "bounce." AC mastered the problem—came up with smooth-running flexible cable that retained high torque strength—made AC cable tops in the industry.

AC is adept at solving problems which result in better end products and lower costs to manufacturers. Our staff and our laboratory resources can perform similar services for you. Your inquiry, directed to any of the AC offices listed below, will be given prompt attention.

We took the inherent BOUNCE out of flexible cable

FOR MORE THAN TWFNTY YEARS EVERY MAKE OF CAR HAS USED ONE OR MORE AC PRODUCTS

• ADAPTERS (Drive) • AIR CLEANERS • AIR CLEANERS AND SILENCERS (Combination) • AMMETERS • BREATHERS (Crankcase) • CAPS (Radiator Pressure) • FLEXIBLE SHAFT ASSEMBLIES • FUEL PUMPS • FUEL AND VACUUM PUMPS (Combination) • FUEL FILTERS & STRAINERS • GASOLINE STRAINERS • GAUGES — AIR (Pressure) • GAUGES — GASOLINE • GAUGES — OIL (Pressure) • GAUGES — TEMPERATURE (Water, Oil) • OIL FILTERS (Lube) • PANELS (Instrument) • SPARK PLUGS • SPEEDOMETERS • TACHOMETERS • TERMINALS (Ignition Wire) • VALVES (Crankcase Ventilation)

AC SPARK PLUG DIVISION GENERAL MOTORS CORPORATION

AC QUALITY PRODUCTS

FLINT—1300 North Dort Hy.
CHICAGO—Insurance Center Bldg.
DETROIT—General Motors Bldg.

We're Scheduling This Ad For 195X

LESS than three years ago, the revolutionary Thompson-engineered ball joint front suspension made the headlines. Already three of today's top passenger cars have adopted it . . . with other car manufacturers soon to follow suit.

Next? It won't be too long before the big news in the automotive world may be the adoption of Thompson's front suspension ball joints for *trucks and tractors, too!*

Then the "big fellers" of the automotive world . . . tractors and trucks . . . will also enjoy the advantages of:

- **Less driver fatigue**
- **Easier, safer steering**
- **Greater over-all stability**
- **Extra space for wider modern engine design**
- **Absence of front suspension and steering bind**
- **Lubrication points reduced from 12 to 4**
- **Increased service life *many times over***
- **Front end overhaul time cut *by hours***
- **Reduced manufacturer's assembly line costs**

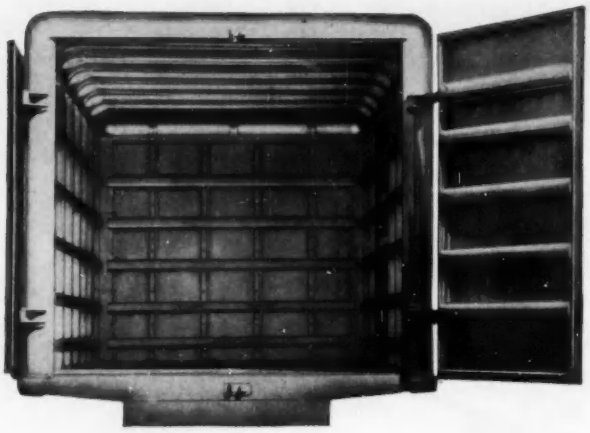
This latest Thompson "Engineered Steering" development is typical of Thompson's cooperation with the Automotive Industry over the past 50 years.

Bring your steering linkage problems to Thompson's experienced engineers. Write, phone or wire Thompson Products, Inc., Michigan Plant, 7881 Conant Avenue, Detroit 11, Michigan, WA 1-5010.

You can count on

Thompson Products

MICHIGAN PLANT: • DETROIT • FRUITPORT • PORTLAND



A great advance . . . permitting flexibility in design, and the reduction of deadweight . . . is made possible by utilizing Parish interchangeable sections of light gage Mayari R, such as you see inside this truck body.

1001 combinations

with interchangeable ready-made sections

simplify lightweight body design

TRUCK-BODY BUILDERS can now design their own lightweight body skeletons to meet practically any requirement.

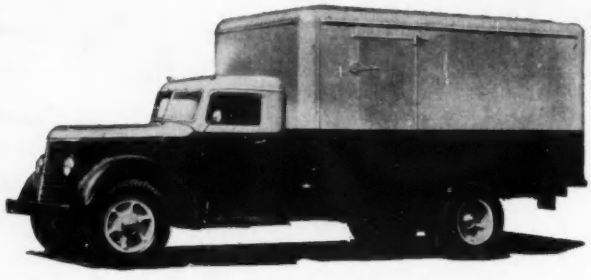
It's an advance made possible by the Parish Pressed Steel Company of Reading, Pa. For Parish developed *interchangeable preformed sections* . . . using Mayari R, a high strength, low alloy steel containing nickel, produced by Bethlehem Steel Company, Bethlehem, Pa.

Steels of this type permit you to make substantial weight reductions, because thin, light sections provide the same strength and safety as thicker, heavier sections of plain carbon steel.

Furthermore, high strength, low alloy steels containing nickel respond to fabrication, including welding and cold-forming, better than does any carbon steel of equal strength. And they also offer greater resistance to impact, wear, and abrasion, thus extending the life of a truck body subjected to hard usage.

In addition, the nickel alloy steels show superior resistance to atmospheric and many other types of corrosion, thereby providing another big advantage to users.

Produced under a variety of trade names by leading steel companies, low alloy, high strength steels containing nickel along with other alloying elements have wide application in the automotive and many other fields.



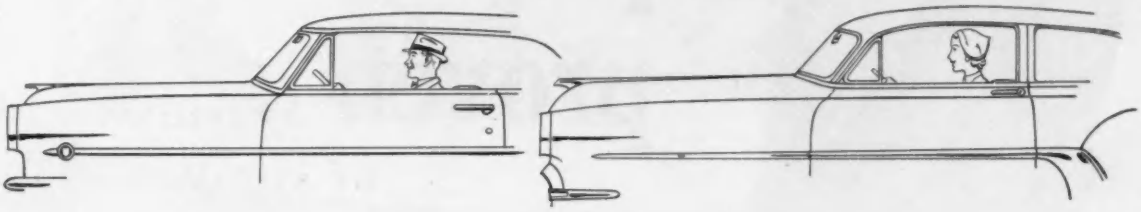
Completed body, built with preformed interchangeable sections, not only meets specific needs of the buyer, but weighs less because superior properties of the nickel alloyed steel allow use of lighter gage.

Consult us on their use in your products or equipment. Investigate how you can cut needless weight, yet increase the payload capacity of your vehicles. Write us today for your copy of the publication "High-Strength Low-Alloy Steels."

EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

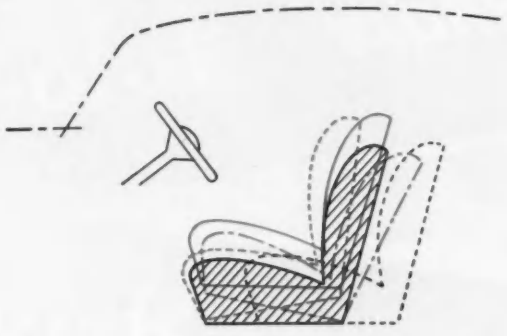
PRODUCTIONEERS from design to finished product



No one has improved the comfort

of the driver of an automobile

more than amp



The **amp Universal Positioning Seat Track,** which provides independent horizontal, vertical and angular adjustments, is a definite contribution to the motoring comfort and safety of the driver. Your inquiry is invited.

AMERICAN METAL PRODUCTS COMPANY

5959 Linsdale Avenue amp Detroit 4, Michigan

PLANTS • Detroit, Michigan • Kalamazoo, Michigan • Union City, Tennessee • Wallington, New Jersey

performance proven *by millions of installations*

- ***"No Kick-Out" feature wins overwhelming approval from car, truck and tractor manufacturers***

Although a comparatively new advancement in starter drive design, the Bendix* Folo-Thru Drive has already proven itself in millions of installations to be the most efficient starting equipment under all operating conditions.

The Folo-Thru type is specially designed to follow thru the weak explosions until the engine actually runs on its own power. Thus, quicker and more dependable starts are assured even under the most extreme weather conditions.

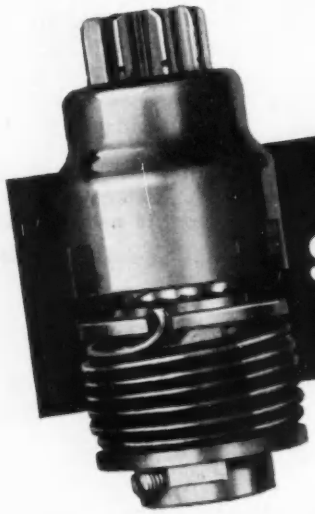
You're right from the start when you specify Bendix Folo-Thru Starter Drive.

ECLIPSE MACHINE DIVISION OF Bendix
AVIATION CORPORATION

ELMIRA, NEW YORK

Export Sales: Bendix International Division, 205 East 42nd Street, New York 17, N. Y.

Bendix folo-thru starter drive

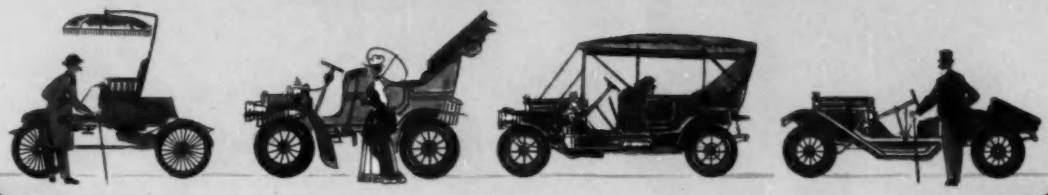


costs less—*Like the millions of Bendix Starter Drives manufactured for the industry, the new Folo-Thru Drive requires no actuating linkage, and the less expensive solenoid may be placed in any convenient position. Result is lower installation and maintenance costs. Complete detailed information is available on request.*

*REG. U.S. PAT. OFF.

Bendix* Folo-Thru Starter Drive Bendix* Automotive Electric Fuel Pump Stromberg* Aerequad Carburetor

WE WERE THERE...



WE WILL BE THERE

Spicer has been through all the phases and cycles of automotive development during the past 50 years. Spicer has been a major factor in the progress of the motor vehicle from a clumsy, noisy machine to a sleek, fleet, worldwide method of transportation.

Spicer now looks forward to its second 50 years of participation in automotive advancements. Working together hand in hand with designers and engineers on the vehicles of the future, the Dana organization will continue to develop Spicer power transmission units that will maintain their reputation as

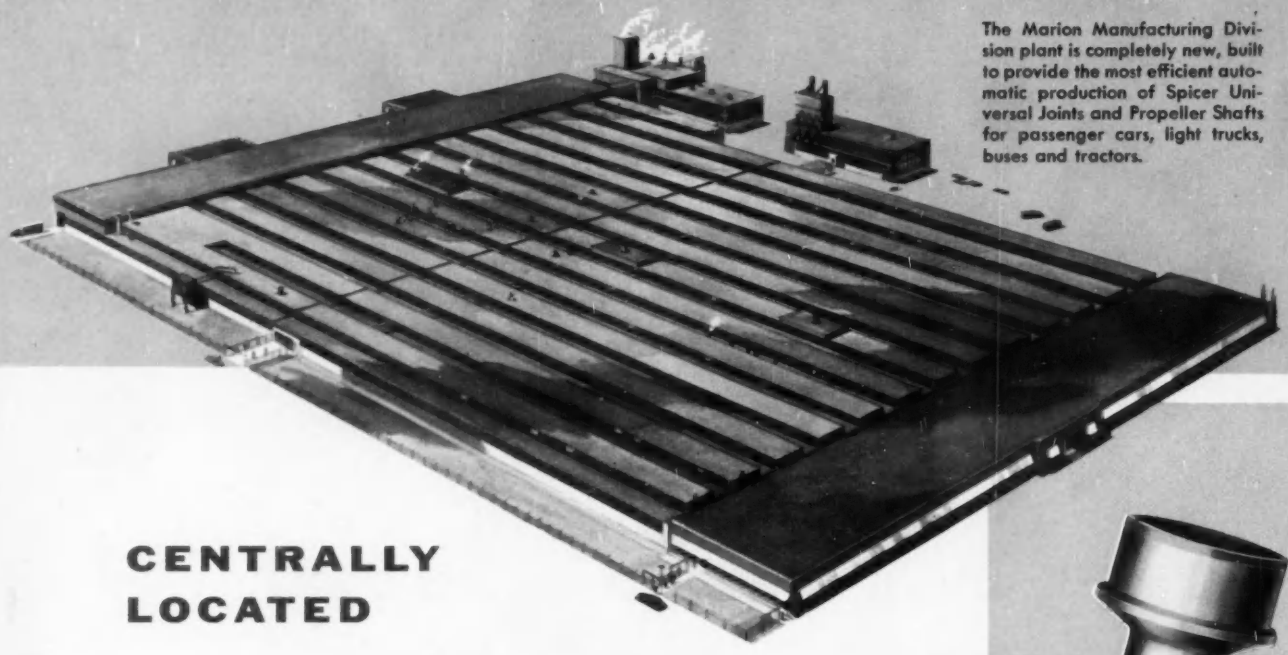
"The Standard of the Industry"

ENGINEERING

DANA

MANUFACTURING

THIS IS THE MARION MANUFACTURING DIVISION IN MARION, INDIANA



The Marion Manufacturing Division plant is completely new, built to provide the most efficient automatic production of Spicer Universal Joints and Propeller Shafts for passenger cars, light trucks, buses and tractors.

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and assuring a convenient, dependable source of supply for the automotive industry

For fifty years, Spicer Universal Joints . . . *first in the industry* . . . have been in volume demand because of outstanding service features:

1. True bearing alignment with rigid one-piece yoke design. *This rigidity is the essence of accuracy.*
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4. Uniform high quality propeller shaft tubing. *Steel meets our special specifications for Spicer propeller shaft needs.*
5. Wide selection of flange and yoke types and sizes to suit each individual requirement.

Spicer facilities are diversified and convenient, to fill your needs efficiently in power transmission units.

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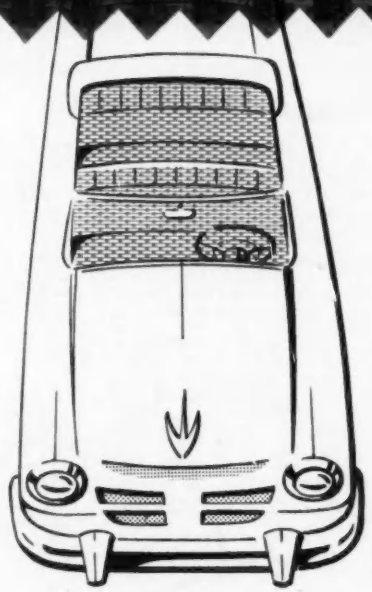

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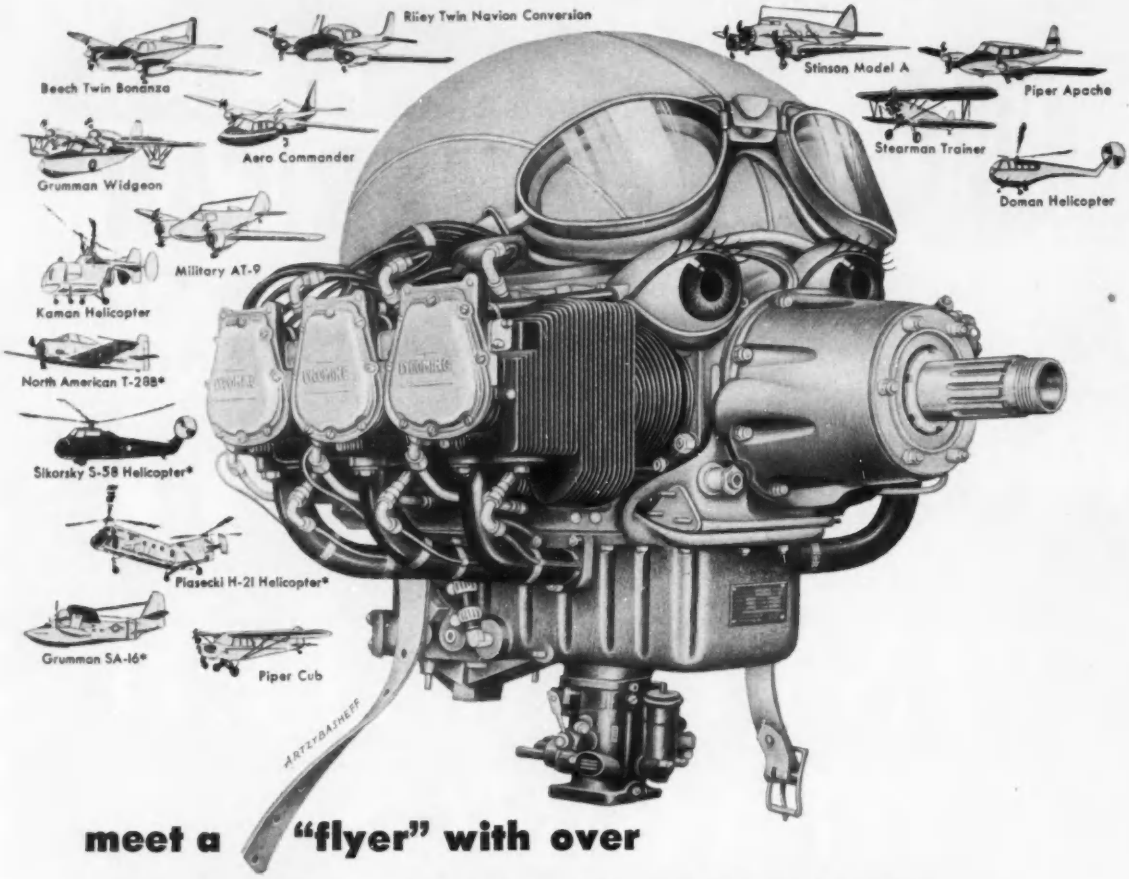

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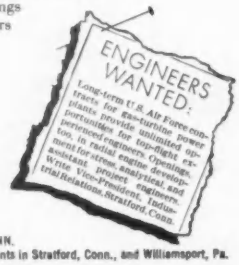

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DIVISION OF AVCO STRATFORD, CONN.
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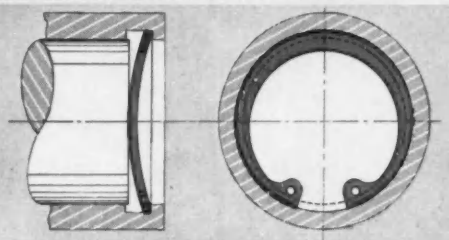
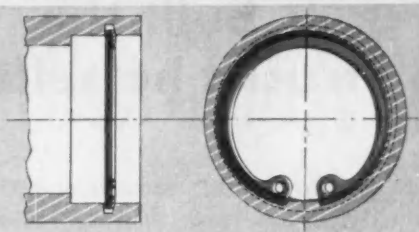
*Wright-Cyclone engine, built by Lycoming under license from Curtiss-Wright Corporation, Wright Aeronautical Division.

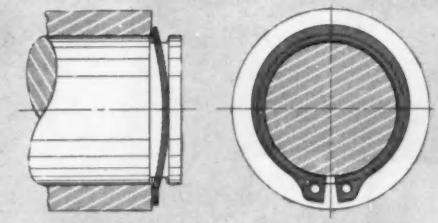
if end-play take-up is a problem
one of these special Waldes Truarc rings can solve it



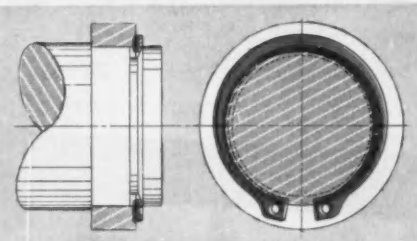
series 5001 · internal type
for bore diameters from: .250 – 1.456 in.



series 5002 · internal type
for bore diameters from: 1 – 10 in.



series 5101 · external type
for shaft diameters from: .188 – 1.438 in.



series 5102 · external type
for shaft diameters from: 1 – 10 in.

bowed WALDES TRUARC RETAINING RINGS

Take up end-play resiliently, damp vibrations and oscillations. Bent like a bow out of plane at horizontal center line. The bowed Truarc ring acts in axial direction like a floating spring without losing its tight grip against the bottom of the groove.

Maximum resilient end-play take-up: .015″ to .020″ depending on size of ring.

beveled WALDES TRUARC RETAINING RINGS

Take up end-play rigidly. When the ring is contracted (or expanded), the tapered edge acts like a wedge moving deeper into the groove and shifting in an axial direction until the ring abuts the machine part.

Maximum end-play take-up, depending on ring size: internal types, .005″ to .043″; external types, .005″ to .040″.

WALDES TRUARC is much more than a better way to hold parts together

Thousands of manufacturers have already found that Truarc Retaining Rings cut production costs and speed assembly by simplifying product design. But that's not all.

Waldes Truarc engineers have extended[4] the use of retaining rings by developing rings that perform *additional functions* while acting as retaining shoulders. Those shown here take up end-play, compensate for wear and varying manufacturing tolerances.

No matter what your problem, there's a Waldes Truarc Ring designed specifically to solve it. Send us your drawings, your questions—Waldes Truarc engineers will work with you, at no obligation.

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WALDES

TRUARC

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WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U. S. PATENTS: 2,382,947; 2,382,948; 2,416,051; 2,420,021; 2,420,341; 2,439,705; 2,441,846; 2,455,165; 2,483,380; 2,483,383; 2,487,802; 2,497,003; 2,491,306; 2,509,081 AND OTHER PATENTS PENDING.

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if the TRUCK DEALER built the trucks he sells—

ZENITH CARBURETORS

would be *his* choice

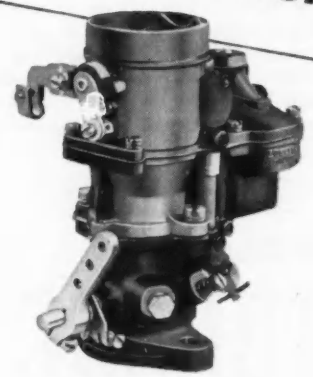
The successful truck dealer is in the business of selling customer satisfaction as well as retailing trucks. For it is obvious that unless a dealer enjoys a substantial volume of repeat business he is going to have trouble operating at a profit.

Therefore, shrewd truck dealers are vitally interested in the performance of such important components as carburetors. It is for this reason that the outstanding performance characteristics of Zenith* Carburetors, under every operating condition, have made Zenith the dealer's choice.

Therefore, it just seems reasonable that if truck dealers were engineering trucks for complete customer satisfaction, performance proven Zenith Carburetors would be their choice for standard equipment.

Further evidence why—if you build, buy, sell or operate trucks, Zenith should be your choice for the finest in carburetion.

*REG. U. S. PAT. OFF.



ZENITH CARBURETOR DIVISION OF Bendix AVIATION CORPORATION

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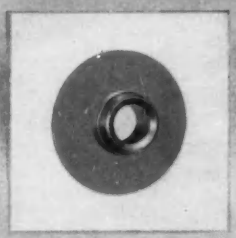
How the design, development and production team at Burgess-Norton made possible

Cost Savings of 17% On this Clutch Hub

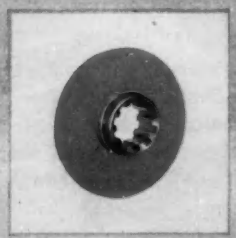
Here is another example of how redesign for modern production methods produced a better part at lower costs. This clutch hub was formerly made from a machined forging. By combining a screw machined part and a stamping through hydrogen-copper brazing, as shown below, production costs were reduced 17% . . . greater control on flange tolerances obtained, and eight stop lugs could be used instead of only four.

The original forged hub design required greater machining time, and often had excessive scrap because of flange thickness variations.

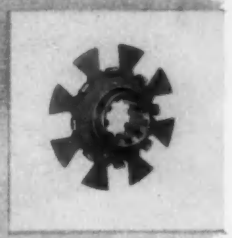
Basic components of the new design are a stamped and formed flange and a screw machined center hub.



The two parts are then assembled with copper rings and brazed under controlled atmosphere conditions to eliminate oxidation.



After the hydrogen-copper brazing operation, the hub splines are cut on horizontal broaching machines.



Final operations are in the stamping department, where spring slots are pierced and stop lugs formed.

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FROM DESIGN THROUGH PRODUCTION FOR BETTER PARTS AT LOWER COSTS

Engineering is one of the important cogs in the complete service offered to industry by B-N. This experienced group works closely with production and metallurgy in designing for low cost manufacture and better end-use performance.

Burgess-Norton facilities and equipment are extremely diversified for the economical production of a wide range of precision parts, and include complete engineering, development, and metallurgy departments. This engineering service is available to you without obligation. If you have a parts production problem, we believe it will pay you to check into Burgess-Norton facilities. Send prints, specifications, or samples . . . or, if you prefer, one of our sales engineers will call, at your convenience.

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Turning at hurricane speed, the camshaft of an engine plays a powerful tune. Its finger-like cams spin in sequence, deftly controlling the explosive diet of each plunging piston. But to perform its important task, a camshaft must excel in many ways . . . and therein lies a story of castings. Quite some years ago, Campbell, Wyant and Cannon realized the wealth of benefits in store for engine user and engine manufacturer if a camshaft could be cast successfully. So CWC put engineering and research to work . . . developed special electric furnace alloys far superior to any previously used materials.

Since that time, CWC has delivered over 40 million cast camshafts . . . saved engine builders well over 50 million dollars. In addition to being produced at lower cost, these camshafts are heat treated to resist corrosion and wear for the life of the engine. They need little machining, are easier to machine and actually extend design possibilities of the engine.

It will pay to consider castings for your product. Many others have found the most important step is to contact CWC.

CAMPBELL, WYANT AND CANNON

FOUNDRY COMPANY

Muskegon, Michigan

GRAY IRON, ALLOY IRON AND STEEL CASTINGS

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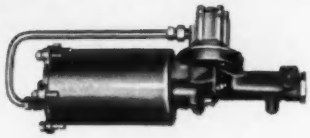
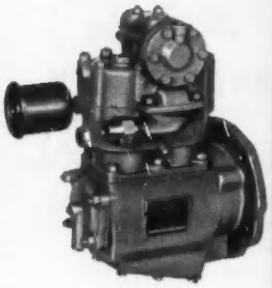
MADE BETTER!

World's Largest Manufacturer of Automobile and Truck Frames Makes Complete Line of Superior Power Brake Equipment and Door Controls for Trucks, Tractors, Trailers, Buses, Passenger Cars

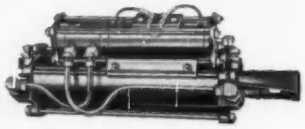
Midland Vacuum Hy-Power—for many years the choice of truck and bus operators and now available for passenger cars — converts ordinary hydraulic brakes into *power brakes*. Simple to install, compact, rugged construction, dependable. Positive braking under all conditions of road or weather.



Midland Air Hy-Power the original air-over-hydraulic power brake system—is still the finest, simplest, most dependable of its type. Provides air operation of tractor by hydraulic brake and control of trailer air brakes by standard hydraulic master cylinder. Lightning fast action, fewer parts, less weight. Sealed against the elements.



Midland Air Compressors offer patented automatic inlet valves built into the cylinder head for greater efficiency, cleaner air, cooler operation, simpler installation. Available in 7.4 and Model 12 capacities. Provide ample reserve braking power for the worst traffic emergencies.



Midland's complete door control equipment for buses includes every type of valve, switch, signal and connection required for safe, dependable, efficient operation. Systems available in both Straight-Air and Electro-Pneumatic operation. For years the choice of leading bus manufacturers. Time-proved the best by every test!

Whether you're a manufacturer or an operator of automotive equipment, you'll profit by insisting that your power brakes, compressors, and door controls be made by Midland. Complete information by writing the factory or through contacting your nearest Midland Distributor.

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NEW PROTECTIVE COATING CHEMICAL FOR ALUMINUM

ALODIZING

Alodizing with "Alodine,"* a new technique in the protective coating of aluminum, was made available for production-scale use in 1946. Since that time Alodizing has largely supplanted the more elaborate, costly and time-consuming anodic treatments in the aircraft and other industries.

Continuous and successful industrial use has clearly demonstrated the simplicity and economy of the Alodizing process as well as the effectiveness of the "Alodine" amorphous coatings, particularly as a base for paint. In fact, the paint-bond that Alodized aluminum provides has been found to be superior to that possible with chromic acid anodizing.

The corrosion-resistance of unpainted aluminum Alodized with "Alodine" Nos. 100 or 300 is excellent, easily meeting the requirements of Specification MIL-C-5541. However, a need for protection of unpainted aluminum, even better than that obtained with chromic acid anodizing, has long been recognized.

NEW IMPROVED "ALODINE" DEVELOPED By ACP RESEARCH CHEMISTS

Several years of intensive research have now led to a new type of "Alodine," designated as "Alodine" No. 1200. This new protective coating chemical forms an amorphous mixed metallic oxide coating of low dielectric resistance that provides unusually high corrosion-resistance for unpainted aluminum. In addition, it forms an excellent paint bond that approaches closely the high quality obtained with the earlier types of "Alodine."

After having been tested for conformance with Specification MIL-C-5541, "Alodine" No. 1200 is now about to go into production.

PROCESS DETAILS

"Alodine" No. 1200 is the only essential chemical needed to prepare the coating bath and the final rinse bath. One of its unique features is that it can be used in tanks in an immersion process, or, in a multi-stage power washer in a spray process, or, with a slight adjustment of pH, with brush or portable spray equipment in a manual process. This means that even where the simple production equipment is not available, or where touching up of damaged coatings previously Alodized or anodized is required, excellent protection and paint bonding can still be obtained with practically no equipment.

All three methods of application easily meet the requirements of Specification MIL-C-5541.

Process sequence for all three methods of application is the same as for other standard grades of "Alodine" such as Nos. 100, 300, and 600, viz.: 1. Pre-cleaning. 2. Rinsing. 3. Alodizing. 4. Rinsing. 5. Acidulated rinsing. 6. Drying.

Coating time in an immersion process ranges from 2 to 8 minutes and in a mechanized spray process is about 30 seconds. "Alodine" No. 1200 baths are operated at room temperatures (70° to 100°F.) and heating is required only if the bath has gotten cold after a "down" period.

RECOMMENDED USES FOR "ALODINE" No. 1200

"Alodine" No. 1200 is specifically recommended for coating wrought products that are not to be painted or are to be only partially painted; and for coating casting and forging alloys whether or not these are to be painted. "Alodine" Nos. 100 and 300 are still recommended for coating wrought products such as venetian blind slats, awnings, etc., that are invariably painted.

RESULTS OF TENSILE TESTS

This new "Alodine" not only retards visible corrosion and pitting, but as shown in the table below, the loss of ductility with "Alodine" No. 1200, both brush and dip, after 1000 hours salt spray was less than for chromic acid anodizing after 250 hours, and for "Alodine" No. 100 and a conventional chromate treatment after 168 hours exposure.

PROCESS	SALT SPRAY EXPOSURE	COMPLIANCE WITH TENSILE REQUIREMENTS OF MIL-C-5541
CHROMIC ACID ANODIZING	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	fails
	1000 hrs.	fails
BRUSH "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 100	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails
CONVENTIONAL CHROMATE TREATMENT	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails

*"Alodine" Trade Mark Reg. U. S. Pat. Off.

AMERICAN CHEMICAL PAINT COMPANY

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CHEMICALS ACP PROCESSES

Now! AIR-POWER steering

BY Bendix-Westinghouse

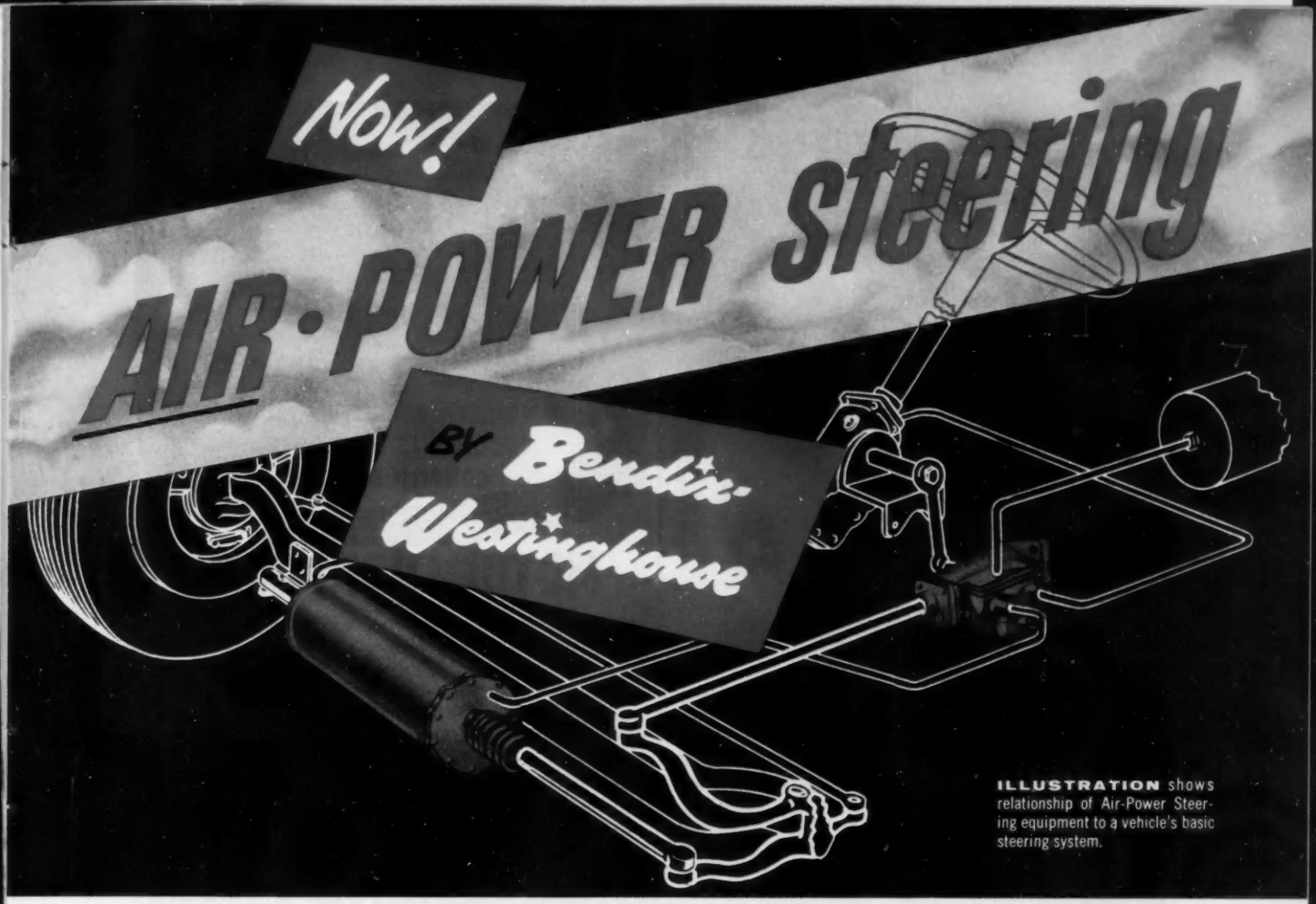


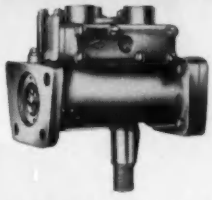
ILLUSTRATION shows relationship of Air-Power Steering equipment to a vehicle's basic steering system.

The only power steering that requires no additional power source!

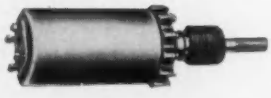
Now you can make the compressor in the air brake system of your trucks or buses pay off two ways—not only as a medium for sure, effortless stops, but as the power source for smooth, effortless steering as well! That's because new Bendix-Westinghouse Air-Power Steering uses the basic air brake compressor as its source of power. Thus, you benefit cost-wise by buying *one* power system *only*—you step up performance because no matter how much weight they are carrying or how slowly they are rolling, the grueling effort required to handle big equipment is eliminated completely—steering, in fact, becomes so easy that even your largest, heaviest models will handle like toys!

For Bendix-Westinghouse Air-Power Steering takes the drudgery out of driving, lets the driver sit back in comfort and "guide" even the biggest jobs—on the highway or off the road, in rain or shine—with complete confidence and without fatigue! Yes, regardless of weight, speed, tire size, road conditions, weather, traffic or size of driver, Bendix-Westinghouse Air-Power Steering provides new standards of safety, ease and efficiency of operation on any hauling or transit job!

Investigate the advantages of Air-Power Steering on your vehicles. Write direct to the factory and learn the complete story of how you and your customers can benefit with this new Bendix-Westinghouse development.



CONTROL VALVE is the heart of the system. Operates in response to the force developed between the steering gear pitman arm and the steering knuckle arm. Delivers compressed air to power cylinder only when steering wheel rim pull exceeds 6 to 10 pounds.



THE DOUBLE-ACTING POWER CYLINDER provides adequate, dependable power for steering assist—is designed to offset road shocks under rough operating conditions.

Bendix-Westinghouse

AUTOMOTIVE AIR BRAKE COMPANY

BENDIX-WESTINGHOUSE AIR BRAKES REG. U.S. PAT. OFF.

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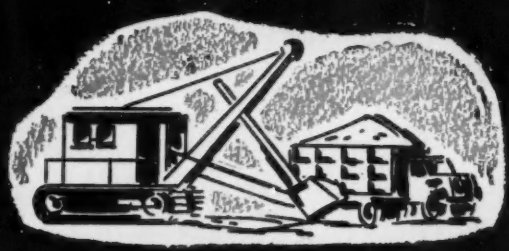

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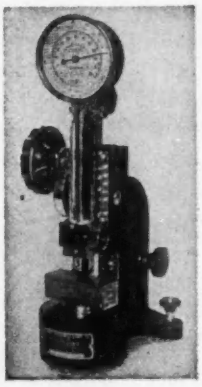

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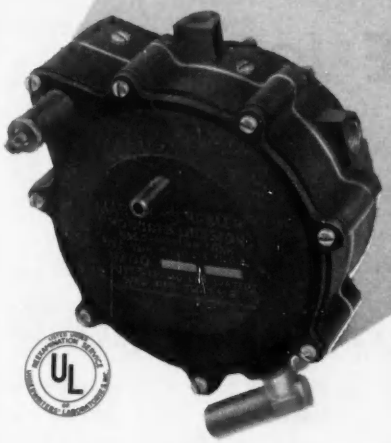

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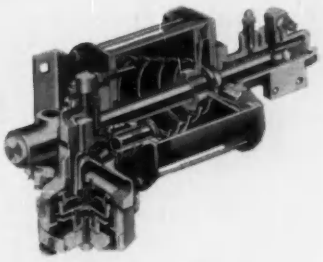

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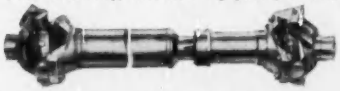

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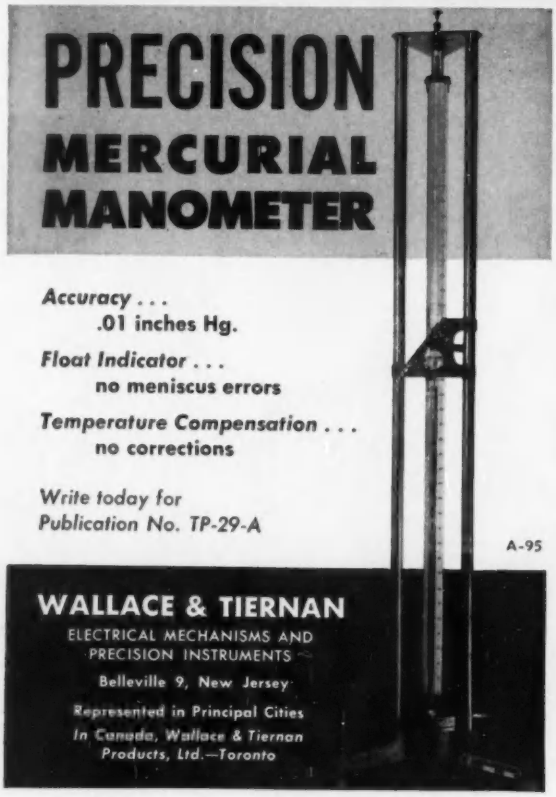
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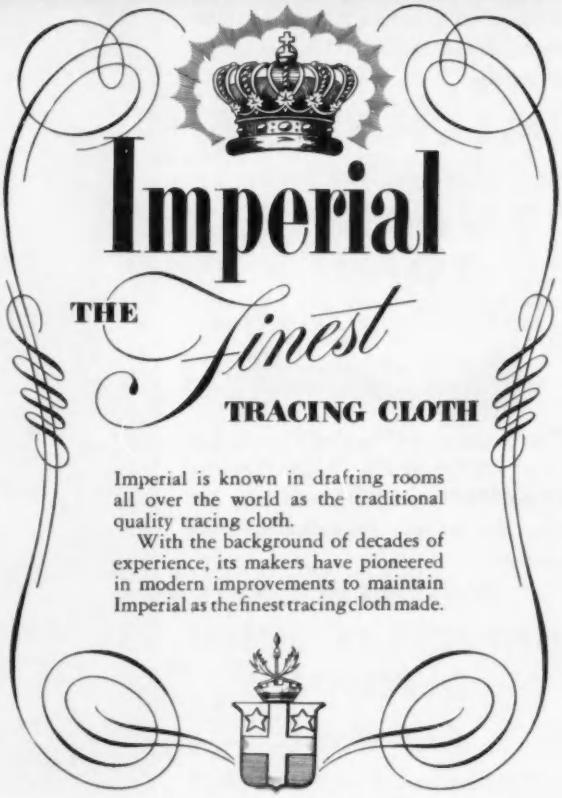
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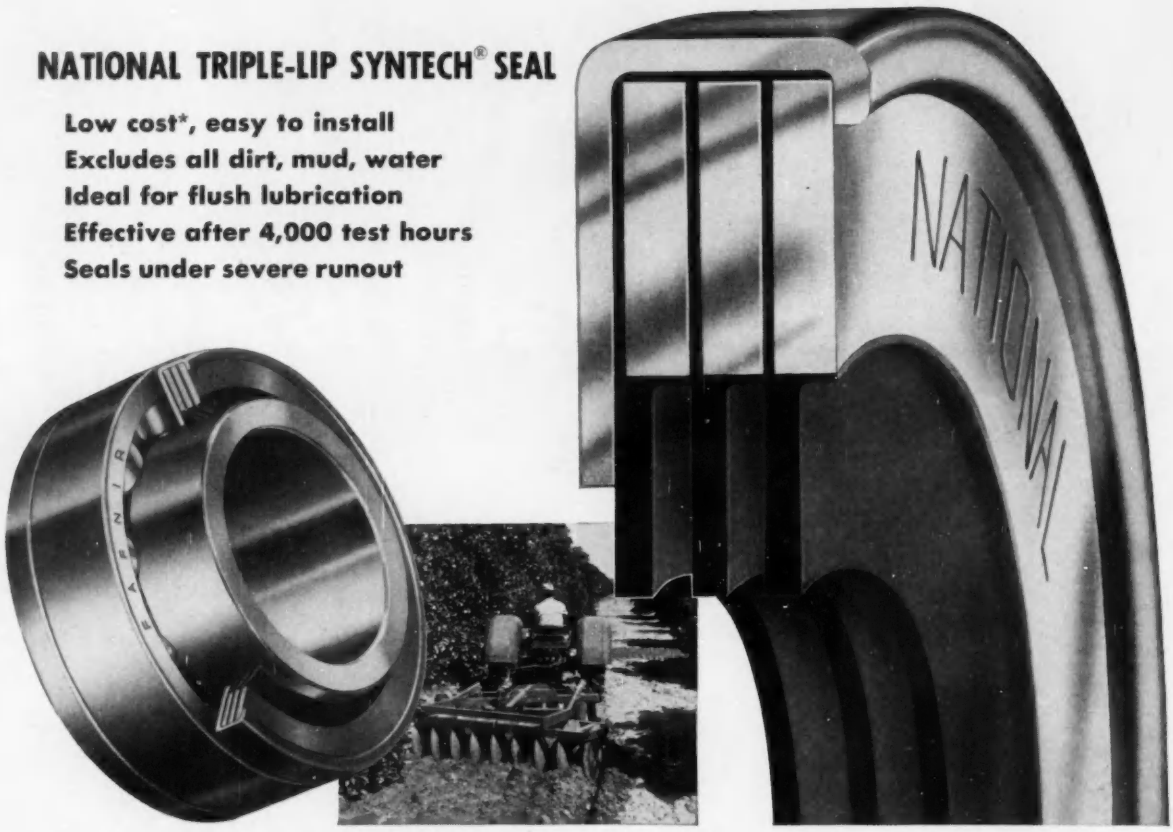

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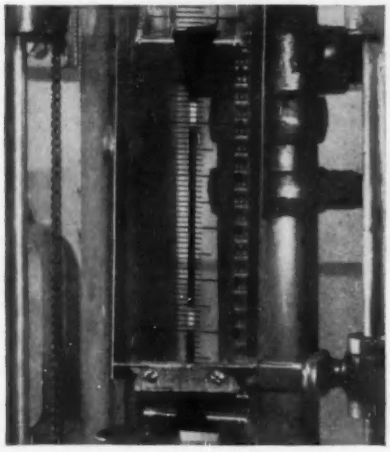

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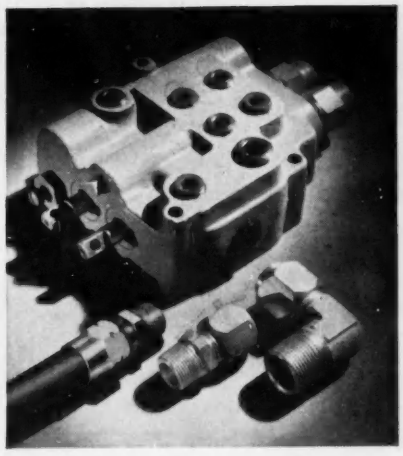

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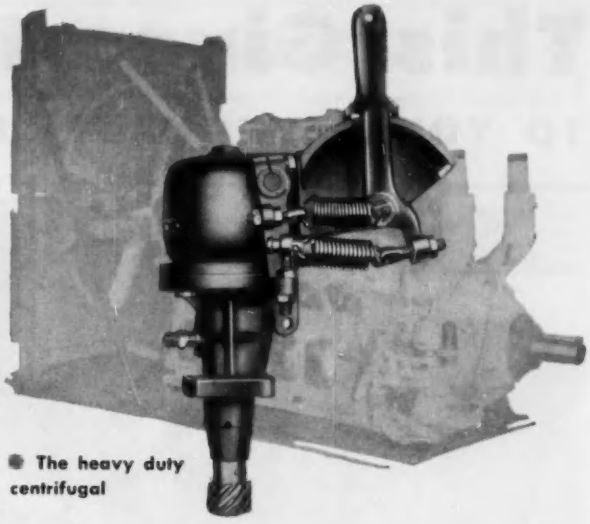

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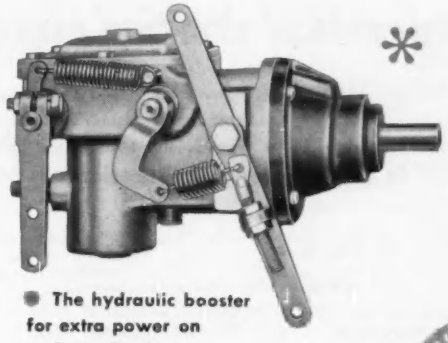

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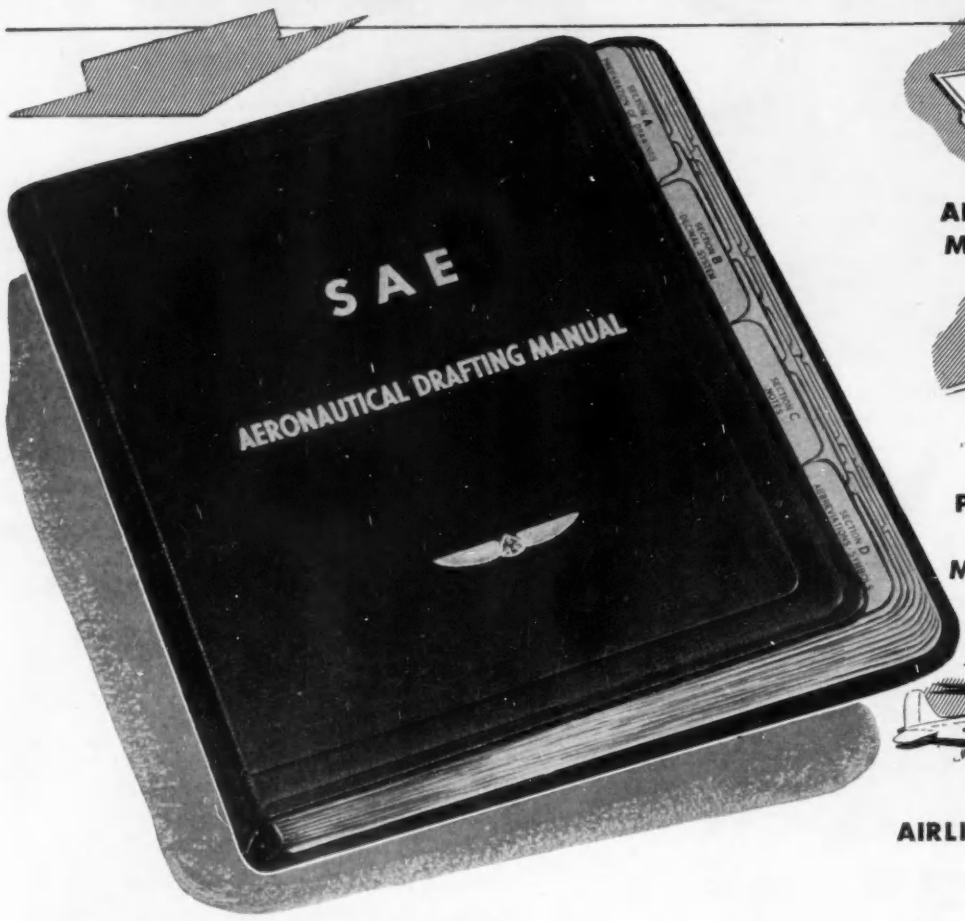

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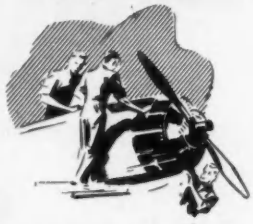

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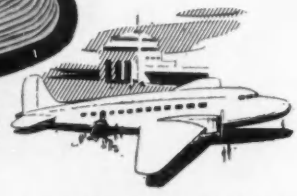

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Allied Products Corp. 160
American Chemical Paint Co. 178
American Felt Co. 182
American Metal Products Co. 165

B

Bendix Aviation Corp.
Bendix Products Div. 16
Eclipse Machine Div. 166
Stromberg-Elmira Div. 137
Zenith Carburetor Div. 172
Bendix Westinghouse Automotive Air Brake Co. 179
Bethlehem Steel Co. 142
Borg & Beck Div., Borg-Warner Corp. 102
Borg-Warner Corp. 155
Bower Roller Bearing Co. 131
Bundy Tubing Co. 152, 153
Burgess-Norton Mfg. Co. 173

C

Campbell, Wyant & Cannon Foundry Co. 175
Clark Equipment Co. 147, 148

D

Dole Valve Company 120
Douglas Aircraft Company, Inc. 130
Dudco Division, The New York Air Brake Company 116

E

Eaton Mfg. Co., Axle Div. 4
Eaton Mfg. Co., Pump Div. 8
Eaton Mfg. Co., Valve Div. 128
Electric Auto-Lite Co. 115

F

Fafnir Bearing Co., The Inside Back Cover
Fairchild Engine & Airplane Corp. (Aircraft Div.) 108, 114
Fasco Industries, Inc. 103
Federal-Mogul Corp. 127
Fuller Mfg. Co. 156

G

Gabriel Company, The 184
Gear Grinding Machine Co., —Rzeppa Joint Div. 119
General Plate Div. Metals & Controls Corp. 12
Goodyear Tire & Rubber Co. ... 7, 154
Graton & Knight Company 122
Great Lakes Steel Corp. 187

H

Harrison Radiator Division General Motors Corp. 141
Hyatt Bearings Div. General Motors Corp. 113
Hydreco Division, New York Air Brake Company 117

I

Imperial Pencil Tracing Cloth ... 184
International Nickel Co. 164
International Packings Corporation 122

K

Kearfott Company, Inc. 110
Keuffel & Esser Co. 134

L

Libbey-Owens-Ford Glass Company 132
Link-Belt Company 146
Lisle Corp. 121
Long Mfg. Div. Borg-Warner Corp. 158
Lycoming Spencer Division AVCO Mfg. Co. 170

M

McLouth Steel Corp. 129
McQuay-Norris Manufacturing Company 144
Marvel-Schebler Products Div. Borg-Warner Corp. 181
Mechanics Universal Joint Div. Borg-Warner Corp. 183
Micromatic Hone Corporation 2
Midland Steel Products Co. .. 112, 176
Miehle-Dexter Supercharger Div. of Dexter Folder Co. 135
Milsco Mfg. Co. 180
Moraine Products Div. General Motors Corp. 123
Morse Chain Co. 139
Muskegon Piston Ring Co. 194
Mycalex Corporation of America . 107

N

National Automotive Fibers, Inc. 169
National Malleable & Steel Castings Co. 111
National Motor Bearing Co. 186
National Truck Leasing System .. 180
New Departure Div. General Motors Corp. 1
New York Air Brake Company 116, 117

P

Packard Electric Div. General Motors Corp. 159
Palnut Company 100
Parker Appliance Co. 188, 189
Parker Rust Proof Co. 14
Perfect Circle Corporation Inside Front Cover
Pesco Products Div. Borg-Warner Corp. 161
Pierce Governor Co., Inc. 191
Precision Rubber Products Corp. . 3
Purolator Products, Inc. 145

R

Raybestos-Manhattan, Inc. Equipment Sales Div. 124, 125
Rinshed Mason Co. 157
Robertshaw-Fulton Controls Co., Fulton-Sylphon Div. 118
Rochester Products Div. of General Motors Corp. 9
Rockford Clutch Div. Borg-Warner Corp. 106
Rohr Aircraft Corp. 126
Ross Gear & Tool Company 5

S

Sealed Power Corp. 143
Shore Instrument & Mfg. Co., Inc. 180
Spencer Thermostat Div. Metals & Controls Corp. 109
Spicer Mfg. Div. of the Dana Corp. 167, 168
Sterling Aluminum Products, Inc. 185
Sturtevant Company, P. A. 182
Superior Steel Corp. 177
Swan-Finch Oil Corp. 180
Syntron Company 182

T

Texas Instruments, Inc. 114
Thompson Products, Inc., Detroit Div. 163
Thompson Products, Inc., Valve Div. 133
Timken-Detroit Axle Div. Rockwell Spring & Axle Company .. 150, 151
Timken Roller Bearing Co., Steel & Tube Div. .... Outside Back Cover
Torrington Co. (Needle Bearings) 6
Tung-Sol Electric, Inc. 99

U

United-Carr Fastener Corp. 149
United States Rubber Co., Engineered Rubber Products Div. 140

V

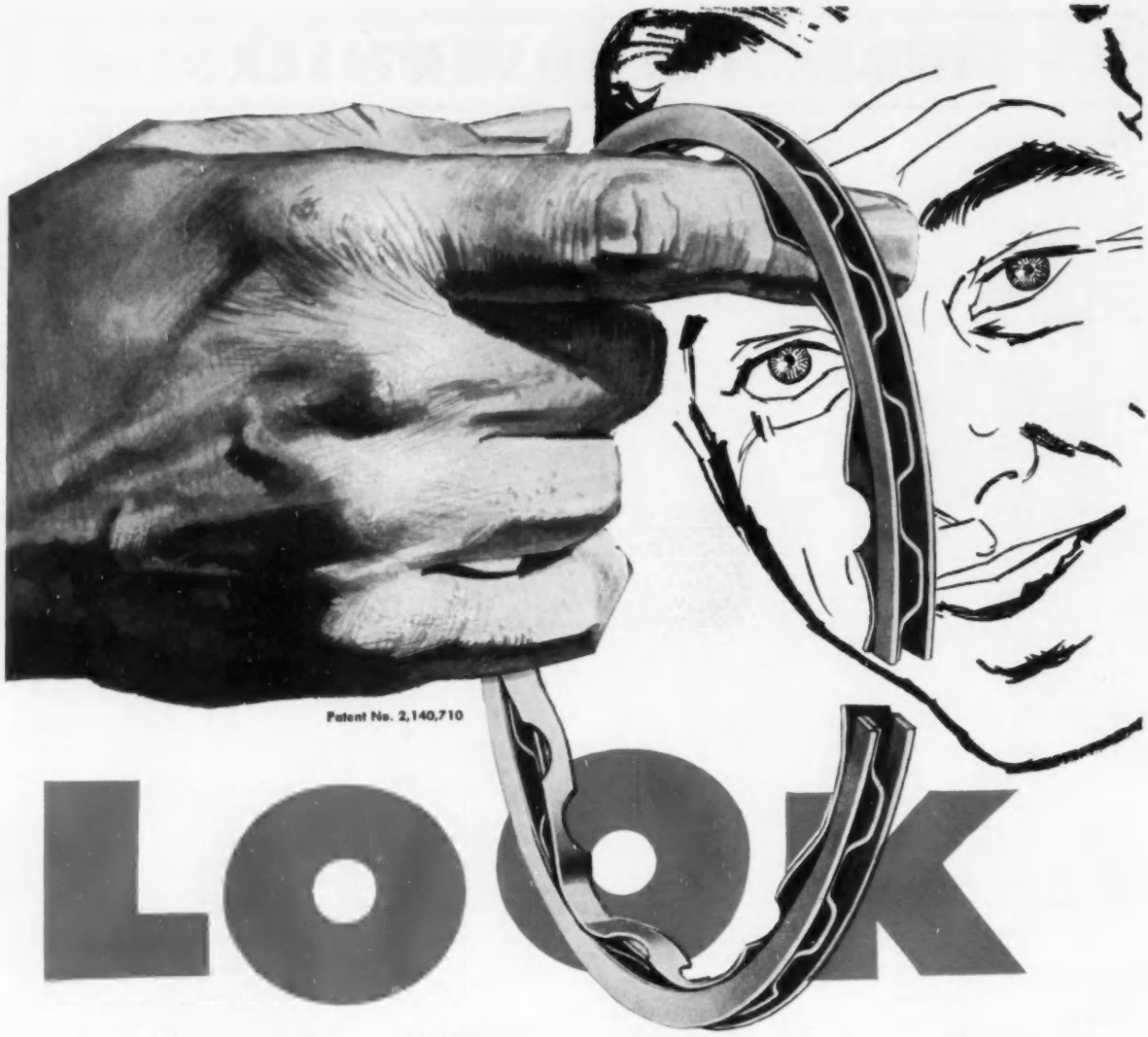
Vickers, Inc. 11
Victor Manufacturing & Gasket Co. 136

W

Wagner Electric Corp. 138
Waldes Kohinoor, Inc. 171
Wallace & Tiernan Products, Inc. 184
Wausau Motor Parts Company 104, 105
Western Felt Works 10

Y

Yates-American Machine Co. ... 101



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MUSKEGON Piston Rings

MUSKEGON PISTON RING CO.
MUSKEGON, MICHIGAN
PLANTS AT MUSKEGON AND SPARTA

Since 1921... The engine builders' source!

You see at a glance that it's something new, different, better—a multiple-piece oil ring that *handles* like a one-piece ring!

But take a *good* look. See for yourself how Muskegon's patented *Unitizing* process holds the pieces together in the right order for quick, easy installation. Then, in the first rush of hot oil, as the engine starts to run, the special adhesive dissolves completely and leaves the parts of the ring free to function independently of each other.

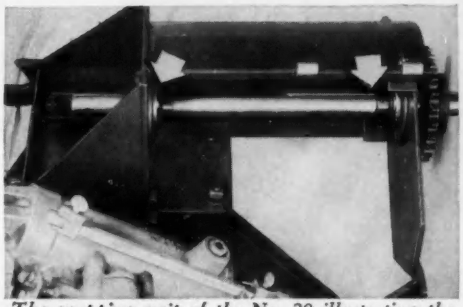
Test Muskegon's CSR-200 rings in your own engines, in your own laboratory. See how the chrome plated rails reduce ring wear and bore wear, scuffing and friction—see how these rings keep the engine new longer and increase oil economy.

And your eyes will be wide with amazement when you learn that the price is just *half* that of chrome plated cast iron oil rings! Write us today.

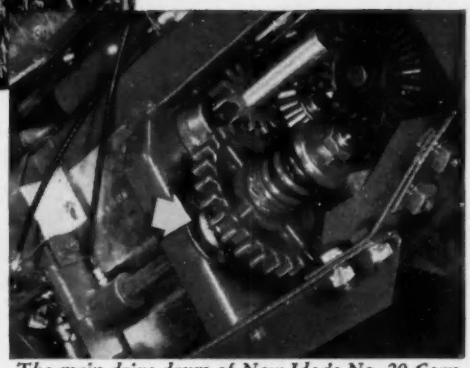
DETROIT OFFICE: 521 New Center Bldg., Telephone Trinity 2-2113

NEW IDEA CORN PICKER

features Popular Idea for Eliminating Friction



The snapping unit of the No. 20 illustrating the use of Fafnir Flangettes



The main drive drum of New Idea's No. 20 Corn Picker illustrating the use of Fafnir Ball Bearing Flangettes

The new No. 20 Two-Row Mounted Corn Picker introduced by New Idea features an extra-large trailing husking bed and rear-mounted caster wheels which bear part of the weight usually imposed on the tractor. Ball bearing-equipped shafts are design advantages which contribute in no small measure to its ability to deliver unusually clean-picked corn.

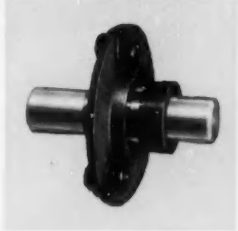
New Idea design engineers found the precise answer to specific bearing requirements in the low-cost, easy-to-install Fafnir Flangettes. These economy units are complete with pressed steel housings, Fafnir Wide Inner Ring Ball Bearing with self-locking collars and efficient seals. Their application assures long, uninterrupted, trouble-free operation with minimum servicing.

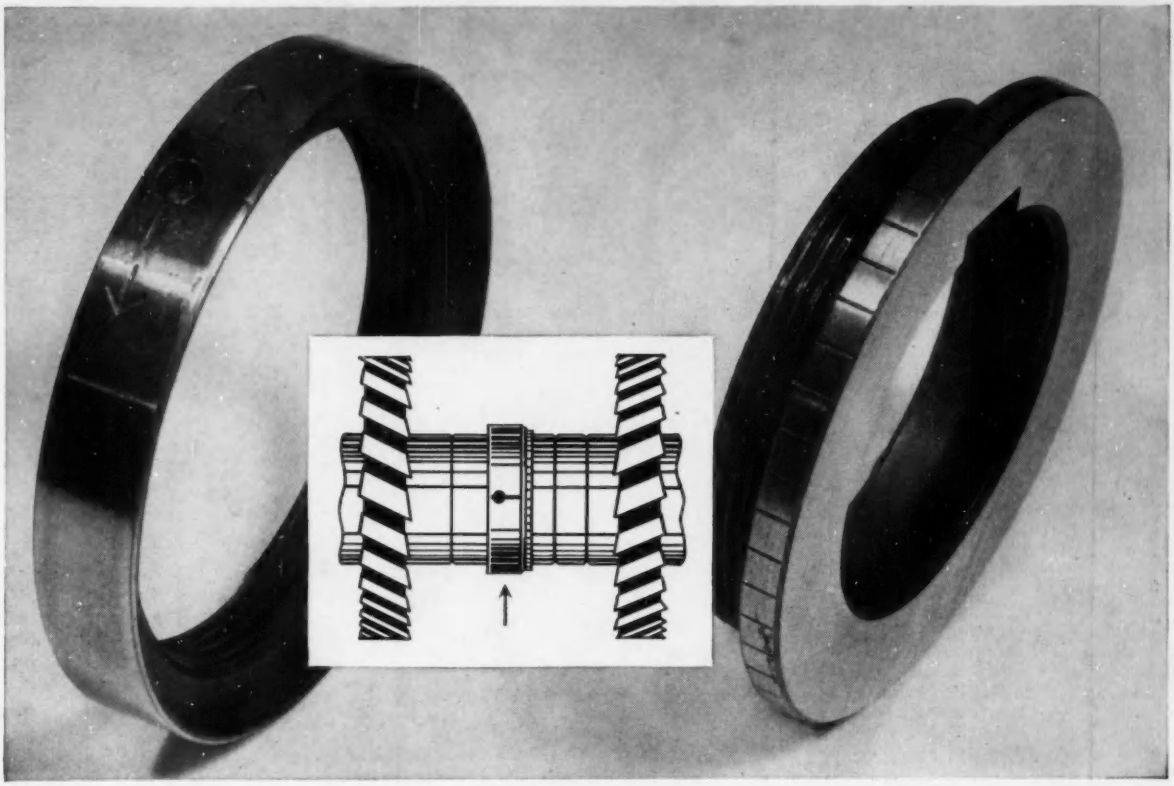
Like New Idea, other manufacturers of farm equipment are turning to Fafnir for precise answers to bearing problems. In addition to a wide selection of bearings, they find most helpful the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the designer's viewpoint and the ability to supply the right bearing for the need. Maybe this combination can help you. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

Fafnir Flangette





Switch to Graph-Mo® steel for spacing collars ends thread damage, eliminates thread grinding

NEAR perfect accuracy is the number 1 requirement of the Dayton Rogers Manufacturing Company, Minneapolis, for its micrometer adjustable spacing collars for milling machine cutter arbors. But when machine operators tightened the collars, they often exerted excessive arbor nut pressure that ruined accuracy and destroyed micrometer threads.

Then Dayton Rogers switched to Graph-Mo®, one of four Timken® graphitic tool steels. They found that Graph-Mo collars can take 20 tons pressure on both sides without disturbing accuracy or damaging threads. It's almost impossible for an operator to exert excessive milling machine arbor nut pressure. Micrometer accuracy is assured for the life of the spacing collars.

What's more, they discovered that the threads maintain their accuracy after heat treating. No thread grinding is necessary. Now Dayton Rogers uses Graph-Mo on all six collar sizes, from ⅜" to 1".

Users also report that Graph-Mo steel machines 30% faster, outwears other tool steels 3 to 1. It has a minimum tendency to pick up, scuff or gall. Responds uniformly to heat treatment.

For dollar-saving information on the use of Graph-Mo and other Timken graphitic tool steels for machine parts, dies, punches and gages, write for the new "Timken Graphitic Steel Data Book" just out. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD — THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING